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EUROPEAN SCIENTIFIC NOTES, VOLUME 34, NUMBER 11,(U)
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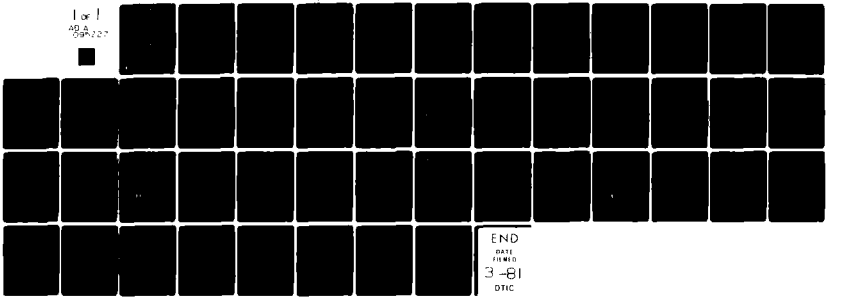

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 34-11	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* EUROPEAN SCIENTIFIC NOTES		5. TYPE OF REPORT & PERIOD COVERED Monthly Publication--NOV 1980 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Wayne V. Burt, Don J. Peters, editors		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Office of Naval Research, Branch Office London Box 39, FPO Ny 09510		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE 30 November 1980 13. NUMBER OF PAGES 41
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

APPROVED FOR PUBLIC RELEASE;DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Communications	Materials Science	Physics
Economics	Medical Physics	
Engineering	Oceanography	
Environment	Operations Research	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This is a monthly publication presenting brief articles concerning recent developments in European Scientific Research. It is hoped that these articles (which do not constitute part of the scientific literature) may prove of value to American scientists by calling attention to current developments and to institutions and individuals engaged in these scientific efforts.

The articles are written primarily by members of the staff of ONRL and oc occasionally articles are prepared by, or in cooperation with, members of the

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scientific staffs of the United States Air Force's European Office of Aerospace Research and Development and the United States Army Research and Standardization Group. Articles are also contributed by visiting Stateside scientists.

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EUROPEAN SCIENTIFIC NOTES
OFFICE OF NAVAL RESEARCH
LONDON

edited by Wayne V. Burt and Don J. Peters

30 November 1980 Volume 34, No. 11

European Scientific Notes is a Class I Periodical prepared and distributed by the Office of Naval Research London in accordance with NAVEXOS-P-35. Prepared and submitted by the scientific and technical staff.

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COMMUNICATIONS

BRITAIN'S JOINT SPEECH RESEARCH UNIT

During the period from the end of World War II until the mid-1950s, government-sponsored research in Great Britain in the area of speech transmission was carried out (or sponsored) by as many as a half-dozen different groups, each with four or five scientists. Among these were units within the Post Office, the Ministry of Defence, and the Home Office. In 1956, in recognition of both the degree to which common requirements existed and the need for a "critical mass" of qualified talent and special facilities, those activities were coordinated and assigned to a newly-formed organization called the Joint Speech Research Unit (JSRU). Until two years ago, JSRU was located in Eastcote, a suburb of London; then it was moved to Cheltenham, about 100 miles to the west.

My host during a recent visit was John N. Holmes, head of the JSRU. His organization includes 15 scientists, of whom 10 are directly involved in speech research and 5 are responsible for computer facilities and associated support activities. Holmes commented that the group includes graduate physicists, engineers, and mathematicians, but has no one with a degree specifically associated with speech research. If the need arises, they consult with university-based specialists in phonetics, linguistics, etc. In this regard, Holmes mentioned that the interested government organizations participate in an advisory and reviewing group, the Speech Research Advisory Panel, and that the panel's representative from academia, Prof. A.J. Fourcin, is a member of the University of London's Department of Phonetics and Linguistics.

Before discussing current research activities, Holmes described a completed project that JSRU is particularly proud of, one which led to the satisfactory development and mass production (by GEC-Marconi Space and Defence Systems, Ltd.) of a series of channel vocoders, the newest version of which is now in general use by Britain's military organizations, among others.

(A *vocoder* is a set of devices which is used to encode/analyze and decode/synthesize speech signals in an efficient manner by making use of special properties associated with the speech signal or its perception. The first practical configuration was described in 1939 by H. Dudley of the Bell Telephone Laboratories. Its design, like that developed by Holmes' group, was called a channel vocoder, which is one in which only the narrowband *amplitude* spectra, centered at certain specific frequencies, are used to characterize the composite voiced signal. The quirk in speech perception that allows this approach to be acceptable is the ear/brain's relative insensitivity to phase errors between the different spectral components.)

That JSRU-designed channel vocoder operates over a standard 2.4 kilobits/sec (kbps) digital link. Its novelty lies in the careful design of the two 19-channel filter banks, especially the synthesis filter bank, and in the digital coding system used. The synthesis filter bank's design leads to improved realism in the synthesized output; the digital coding system provides the required reduction in data rate (from the 56 or 64 kbps rates used in conventional "toll"-quality digital transmission systems) while maintaining acceptable fidelity, even in the presence of errors caused by a noisy link. Many details of the design were described by Holmes in a paper published earlier this year ("The JSRU Channel Vocoder," *IEE Proc.*, Vol. 127, Part F, No.1, Feb. 1980, pp 53-60). In the course of our discussion, he expressed mild consternation over the fact that, despite its quality, the newest version has been given the less than complimentary name, GROWLER.

Currently, the JSRU is involved in four areas of research: speech synthesis from stored phonemes, low bit-rate coding of speech for transmission, automatic recognition of connected-word speech, and the enhancement of intelligibility of speech signals that are rather deeply embedded in wideband noise.

The first of these four projects was only mentioned in passing; we had little time to discuss it. Its goal is to design a system which provides "spoken" instructions, guidance, or numerical information to a user in response to his actions or queries (not necessarily oral inputs). One possible application was mentioned: the use of automatic announcements within the telephone system.

The obvious advantage of using phonemes rather than words as the basic elements of speech is that a much larger vocabulary can be "constructed" from the more basic elements, thereby saving on the memory capacity required in the system. The hoped for advantage of word building based on stored phonemes rather than the synthesis by even-more basic "articulation features" (the physiological bases) of speech is that more realistic sounding speech can be generated for a given level of system complexity.

Dr. Barry C. Dupree discussed transmission-related speech coding with me. Dupree is involved in the development of formant vocoders which are capable of synthesizing speech of high quality but

are limited in their link data rate to 1.2 kbps. (The *formant* vocoder is one in which the voiced signal is characterized by specifying only the center frequencies and the relative amplitudes of the significant peaks [formants] in the spectrum of the speech signal.)

Dupree achieves the bit-rate reduction through a variety of data-smoothing techniques, the most effective being the use of a variable interframe period. Frames of formant data (or an indication of the occurrence of an unvoiced interval or silence) are derived at the analyzer every 10 msec from a 3 msec-long sample of the waveform. If *all* of the derived frames were transmitted, the 100 frames/sec rate would correspond to a bit rate of about 5 kbps. But the 10-msec resolution available is only required infrequently for satisfactory reproduction; an average rate of 20-30 frames/sec has been shown to be suitable.

The scheme for choosing which frames to send is best understood by considering how the receiver (synthesizer) processing is done. The receiver either performs linear interpolation between two successively received frames of data or it holds constant the values represented by a frame of data for the interframe period following that frame. Knowing this, the transmitter chooses which of the available frames to transmit so that the receiver will be able to synthesize an acceptable reproduction. The transmitter's analyzer appends one bit of data to each frame to specify the mode of interpolation to be used by the receiver in that interframe period and it also appends a few bits of data to specify the number of 10-msec intervals included within that interframe period.

A demonstration of the system's operation was provided from prerecorded tapes of the uncoded inputs and the synthesized outputs. For many of the samples, I found it difficult to distinguish the uncoded original from the output speech. (A loudspeaker was used in the demonstration rather than headphones). But, for one particular speaker, the outputs were consistently of poorer quality. Dupree commented that that speaker's nasal characteristic had exposed a shortcoming in the system's spectrum analysis algorithm (in those applications where good low-frequency response, below about 300 Hz, was desired). The problem arose from the attempt to estimate *all* spectral components, even the very low frequency ones, from the 3 msec-long samples. He plans to modify the analysis procedure.

The vocoder, in its present form, is *not* a real-time processor; but a special-purpose, high-speed hardware version is now being developed for JSRU by the Plessey Company, Ltd. Those modifications now being considered by Dupree are such that the new equipment is expected to accommodate them. Delivery of the real-time vocoder is expected early next year.

Dr. John S. Bridle described his work in the two other JSRU research projects. The first project is the development of an algorithm for automatic recognition of connected-word speech which provides the capability for use by a single speaker. A contract has just been let to Logica, Ltd., for the design of a real-time system which will implement that algorithm. Delivery of several units, for use in field research activities, is expected in late 1981 or early 1982. As presently envisioned, the system will be capable of working with a total vocabulary of about 200 words. Within that full set, operational subsets (of up to 50 words each) will be specified by the user. Then, when ready to employ the system, the user orally specifies, by some designator, which subset he/she wishes to use. The specification of a subset also includes a set of rules for the word sequence in a phrase; for example, subset "alpha, baker, seven" might indicate a vocabulary of 35 specified nonnumerical words and the 10 decimal digits, with the rule that an acceptable phrase starts with a nonnumerical word and ends with a decimal digit. Intermediate word-sequence rules might also be imposed.

The system operates by describing each admissible word as a sequence of spectral templates. The templates chosen are the data developed by the previously-described channel vocoder, GROWLER. Processing of input signals involves the parallel comparison of the test signal's spectral templates with those of the vocabulary in the admissible subset. Periods of silence are used for coarse synchronization, but no assumption is made about the existence of well-defined silences between words. A dynamic programming approach is used to account for expected time-scale variations in spoken versions of the same word. While all this is going on, a scoring method is used to measure the quality of the "matches" developed between the input sequence and the individual allowable words. The process starts by comparing the input to *all* a priori admissible words, but, as the match proceeds within a word, those allowable words which exhibit significantly poorer matches than the best are automatically rejected. In that manner, the total processing load is reduced considerably. After the connected set has been so processed, the system estimates the location of word interfaces and estimates the best connected-word sequence represented by the processed data.

Bridle described the system as one similar in many respects to the Nippon Electric Company's DP-100 unit, but he feels that his algorithm may be somewhat more efficient than theirs with respect to the computational "power" required. In any case, when the real-time test units are delivered in about a year, he sees the need for a set of demonstrations and field evaluations by interested parties to determine when and where such systems will be appropriate.

The second project Bridle described was concerned with efforts to extract speech signals from a high-level, wideband noise background. Again, starting from a GROWLER configuration, each of the contiguous-channel outputs in the multichannel filter bank is processed by a level-sensitive gain function. Channel filters with low output levels have their outputs suppressed with respect to those channels with higher output levels. In effect, the lowest levels are considered estimates of the noise-only level. The recombination therefore highlights those subbands which, presumably, had signal components within them, thereby enhancing the intelligibility of the speech signal. Studies of the "optimum" weighting function have been performed and were reported upon, by M.J. Irwin of JSRU at this year's International Conference on Acoustics, Speech, and Signal Processing. By use of a weighting function designed to act as an estimator which minimizes the mean-squared error between the observed signal and the underlying speech, Irwin showed that a 3 db improvement in signal-to-noise ratio is possible, if the unprocessed signal-to-noise ratio is 0db. The demonstration provided during my visit, again by means of a loudspeaker rather than headphones, was quite impressive. A signal whose presence could otherwise barely be detected was transformed into one in which the spoken digits could be heard reasonably clearly. The JSRU researchers reported that, on a quantitative basis, for the weighting function described, an unprocessed signal whose digit-word inputs could be interpreted with only 40-percent accuracy was improved to one with 80-percent accuracy.

My visit to JSRU introduced me to a dedicated and capable group of researchers who deserve a more general level of recognition among American researchers. In the April 1979 issue of the *IEEE Transactions on Communications*, a tutorial paper on speech coding was presented. Over 100 references were listed; not one from JSRU was among them. In the June 1980 issue of the *IEEE Spectrum*, a review article on speech recognition systems listed many experimental systems. JSRU's was not among them. Those appear to be oversights. (Philip Fire)

COMMUNICATIONS R&D AT SWEDEN'S TECHNICAL HIGH SCHOOLS--PART I

The "piece-wise linear" English translation of the Swedish term *tekniska högskolan* (TH) is *technical high school*, but, as many of *ESN*'s regular readers know, such a naive attempt at translation could result in a serious error in interpretation. I've recently visited the four THs in Sweden, all prestigious, all grantors of the hard-to-get Tekn.D. degree. At two of the schools, that translation "joke" was referred to by staff members, albeit self-consciously, since everyone I met within the Swedish university system understands and speaks English very well.

Two of the four THs, those in Lund (LTH) and Linkoping (LiTH) are called Institutes of Technology within the university structures of their respective cities. The other two are autonomous institutions, administratively separate from their city's universities. They are the Kungliga Tekniska Högskolan (KTH), known in English as the Royal Institute of Technology, in Stockholm; and the Chalmers Tekniska Högskolan (CTH), referred to in English as the Chalmers University of Technology, in Gothenburg.

My short visit to KTH covered the activities of three of its institutes (i.e., departments): Speech Communication, Telecommunication Theory, and Telecommunication Networks and Systems.

Prof. Gunnar Fant, head of the Department of Speech Communication and a recognized authority in the field, described the activities now going on within that organization. Some acknowledgment of the evolution of its interests is found in the fact that, at present, a proposal is being considered to change the name of the department to "Speech Communication and Music Acoustics." In general terms, the Speech Transmission Laboratory's interests are the same as those described over four years ago in *ESN* 30-2:55 (1976), namely: natural speech production; speech analysis, synthesis and perception; and aids for the handicapped. The projects have matured in a number of respects, notably in the degree to which some of their device-oriented activities are being focused on realization by microcomputer-based systems. Prof. Fant was quick to point out that the group has very little current activity in the area of speech encoding for transmission, the subject I had originally asked about in arranging for my visit to his group. Their only current effort in this area is the implementation of a system to compare various strategies for digital encoding of speech. The

systems under test are compared to a reference system into which multidimensional analog distortions have been introduced. Subjective "matching" of the test system's output to the reference system's distorted output provides a quantitative measure of the "equivalent" distortion produced by the digital encoding process.

Their activities in the areas of speech synthesis and speech recognition were demonstrated during my visit. In the case of speech synthesis, the system operation is dependent upon character text-to-speech transformations based upon a system of linguistic rules. Different sets of rules have been developed for Swedish and English; other languages and regional dialects are also being considered. The system which was demonstrated scans a set of input characters (in this case, entered by typing at a standard computer terminal; in other cases, from an optical character reader [OCR]). From the in intonation of its output when a question-sentence was entered, the system appeared to operate at a level more complex than that of isolated words, i.e., at the phrase level, at least.

The characters are grouped into words, punctuation is noted, and numbers are recognized as a special case. The number-handling algorithm provides a very natural-sounding spoken version of the full number, not merely a list of digits. (As an aside, when the ten-digit sequence, 1 through 0 was entered, the "spoken" response was "one billion, two hundred and thirty-four million,..." The system had obviously been taught the American system of designating large numbers rather than the British system.)

When the numbers have been treated separately, the system then determines whether the next letter-text sequence, grouped into a word, should be treated by a table-lookup procedure (because it had previously been identified as one which did not fit into the pronunciation rules of the language that had already been specified). If so, the computer proceeds to generate the required speech synthesis signals from the table. If not, the linguistic rules are used. The *art* in such a system design is the tradeoff between handling those special cases in this "brute-force" manner, ignoring their special character (and therefore admitting errors or ambiguities), or mounting an effort to revise the basic set of linguistic rules. That sort of tradeoff procedure is still going on during the development phase of the project. (For example, as a result of the system's erroneous responses to an English test sentence which included a group of words, all with a different correct pronunciation of the letter sequence OUGH, the comment was made that they might now add such words to the table-lookup branch in the program.)

As noted previously, the group has programmed linguistic rules for Swedish and English. One odd variation of their system was demonstrated: the synthesis of an American accent interpreting Swedish text. The lilt of Swedish was gone and was replaced by a splattering of hard *rs* in the midst of a Western twang.

All of this effort on linguistic rule generation is coupled to an ongoing attempt to develop a microcomputer-based implementation. The goal is a set of designs for devices to be used in speech prosthesis applications and, when combined with an OCR, as a reading aid for the blind. The group also sees application toward the mass production of "talking books" for the blind. In this case, the publisher's tapes (or disks), which are now being used to control the production of the page-printing plates, can be used almost directly to provide the textual input to their speech synthesizing system. The output would be a master tape used to produce the cassettes which would be distributed to the blind.

In general support of these efforts, the group at the Speech Transmission Laboratory (and Prof. Fant in particular) are also studying natural-speech generation and perception mechanisms. The speech-generation studies are done with a view toward generating more realistic sounding synthetic speech and also as an aid in the diagnosis of speech impairments. The standard technique of electromechanical analog models is used extensively; Fant's latest interest is in the application of Laplace (rather than Fourier) transform techniques to analyze the time-varying source and filtering functions within the vocal tract. He feels that the technique provides a more accurate temporal description of the emitted signal than do alternate methods which derive a result based upon the product of the two spectral functions which describe the characteristics of the vocal "source" and the vocal tract "filter." His method calculates the output as the sum of a set of glottal-damped and undamped oscillations whose parameters are based upon mechanical actions with the vocal tract.

Speech *recognition* activities within the group are limited to the development of isolated-word-recognition systems. The system which was demonstrated was one which uses a relatively straightforward pattern-recognition approach to the problem of recognizing which one of a restricted vocabulary of words was spoken by a single speaker, the same speaker who had "trained" the system. A microcomputer-based implementation of this system is also under development.

To "train" the system, the speaker enters each word into the vocabulary through a keyboard and also by providing three spoken versions. The waveforms of the spoken signals are band-limited (to 4 ~~kHz~~), then sampled at an 8 kHz rate. Digital processing results in three sets of sampled (amplitude) values: one for the "total" 4kHz-wide version of the waveform, a "base"-band version (low-pass filtered to about 600 Hz) and its complementary high-pass-filtered version. In addition, zero-crossing rates are estimated. Three vector representations are associated with each word entered into the vocabulary: a "mean" vector, one whose components are related to the mean values associated with the three training versions of each word; and a pair of "extreme" vectors whose components are related to the maximum and minimum values of the training set. These vector components, called *features* in the pattern-recognition context, are *not* merely the sample values themselves, but are general functions of those values. For example, one such feature is the set of "on-and-off" pulse widths of the filtered waveform, suitably normalized to a total wordlength.

In operation, the system derives the same set of features from the test input. A minimum weighted-mean-squared-error criterion is used for the matching algorithm; the "art" lies in the selection of features (as few as possible) and the corresponding weighting vector which, in combination, will provide the required discrimination among the words in the vocabulary. In the case of the system which was demonstrated, these two critical factors are fixed; a more sophisticated system would be one designed to adapt its processing algorithm to the vocabulary right after its training period had ended (by choosing a suitable set of operational features from a larger set of preconceived, *possibly* useful features). In the context of an implementation by a microcomputer-based system, however, the fixed algorithm approach is considered acceptable for limited applications.

As noted previously, the department's interests have been broadened to include more studies in the musical acoustics area. Besides the previously reported work on computer-composed music, they are also studying the acoustics of musical instruments (especially violins and guitars), the mechanism of the singing voice, and room acoustic models. Within the short time available for my visit to the department, this set of activities was not discussed.

In the absence of Prof. Lars H. Zetterberg, head of the Institutionen für Teletransmissionsteori, (TTT), my hosts for a visit to that department were Dr. Torbjörn Ström, Zetterberg's assistant, and Dr. Lars-Erik Eriksson. Eriksson, until recently a member of the department, had just joined the Swedish Telecommunications Administration. He was in the process of transferring his "office" at the time of my visit.

TTT's research program has five components: information theory and communication systems, signal processing, circuit techniques, computer systems, and, as a step in the direction of multi-disciplinary studies, a new project called "Telecommunications in Society." The latter project is supported by a foundation which was established in 1964 by the Parliament in commemoration of the Bank of Sweden's 300th anniversary. The foundation exists to provide research grants to organizations for studies of the social consequences of technological, economic, and societal changes. Communications in general, and telecommunications in particular, have been identified as particularly significant fields of technology for consideration; more than half of the 14 grants currently in force are, in some sense, communications oriented. TTT's involvement, at present, is as part of a team of four organizations, the other three being the Economic History Department of the University of Gothenburg, the Economic Psychology Department of the Stockholm School of Economics, and the Nordic Institute for Society Planning (in Stockholm). The team, operating under one of the 14 grants, is directing its efforts to an analysis of telecommunications' impact on business and other organizations. In particular, TTT is to study the development of telecommunications in historic perspective, the expected impact of office automation, and means by which facsimile and picture-phone conference facilities should be implemented. At present, Zetterberg and Ström are personally involved in this activity. They expect to support one doctoral candidate as a member of the team starting this year.

In the information theory and communication systems area, two projects are being pursued: low data-rate coding methods for moving pictures, and the development of a set of computer programs to perform analyses of fiber-optic communication systems operations. Their approach to picture coding is to employ simulation programs to evaluate predictive coding schemes in conjunction with adaptive quantization and delayed-decision feedback. Preliminary results on this project were presented at the 1979 Picture Coding Symposium. Since then, improvements have been made, and now they report that, for a TV-formatted picture with 313 lines per frame at 2 bits/picture element, the picture's degradation

in quality is almost undetectable. Further efforts on the same problem which involved the use of statistical coding in conjunction with a Huffman coder, were described to me. This latter system operates at rates less than one bit/element. Demonstrations of these systems were not available during my visit; the required equipment and test tapes were at the Swedish Broadcasting Company's laboratories where they were being evaluated.

In the fiber-optic systems analysis project, Dr. Eriksson and two doctoral candidates had been refining computer programs which provide an interactive system design and evaluation capability. Those programs operate on their DEC PDP-11 system. The programs were designed to evaluate the probability of error for digital signals, the spectrum of the "equivalent" input noise, and the transfer function of the receiver's input stage. The effort will be continued; one of the candidates, Lars Egnell, will apply the program to study the error probability in high-capacity monomode systems, while the other candidate, Dan Kallgen, will concentrate on the evaluation of medium-capacity systems operating with ungraded fibers.

In the signal processing area, Gunner Ahbom, under Zetterberg's supervision, is designing a microprocessor-controlled, special-purpose hardware system to detect "spikes" in electroencephalograms. The system is meant to help in dealing with the diagnosis of epileptic incidents. Another student, Anders Forsén, is concentrating on industrial applications of signal processing for the marine and the electric power industries. In the former case, he is estimating the statistical properties of underwater acoustic schemes to measure ship speeds. The latter project is a computer program development to support a system for load-flow computations in large, multiple-source power systems.

Circuit technique studies are concentrated on the analysis and implementation of periodically time-varying, linear systems. These are currently being implemented by employing switched-capacitor filters. (In such a filter, an equivalent resistance may be simulated by periodically switching the electric-charge flow path between a pair of condensors of different capacities. The value of the equivalent resistance depends upon the difference in capacity and the rate with which switching occurs.) Such filters are gaining acceptance because they are suitable for implementation in an integrated circuit configuration. The ease with which the characteristics of such filters can be varied, i.e. merely by changing a "clock" rate signal which controls the switching function, makes the technique especially attractive for use within adaptive signal processing systems. Sven Signell, working under the supervision of Dr. Ström, has analyzed a model which includes the effects of non-ideal components on the system operation. He considers the elements to be piecewise-linear but continuously varying. The input signals are either deterministic or cyclostationary stochastic; the analysis derives an expression for the system impulse response and also derives relations between the input- and output-signals' means and autocorrelation functions. A report on this analysis effort has been deferred, awaiting the completion of a related hardware project.

That project, a cooperative one involving TTT with representatives from the Swedish Telecommunications Administration, the SRA Communications company and HAFO (a Swedish fabricator of integrated circuits) is meant to design, fabricate, and evaluate an LSI version of such a filter. The unit has been built, but the evaluation is not complete.

The other TTT project we discussed was one designed to modify and update its in-house PDP-11 computer system, a facility which supports most other activities within the group. They are building and integrating special-purpose hardware to provide real-time high-speed processing capability, and they are performing a set of tests to determine how best to display large sets of data to an interactive user. Different methods of "scrolling" on CRT terminal displays were being evaluated; conclusions were not yet available.

The third department which I visited at KTH is called Telecommunication Networks and Systems. Its head is Prof. Stellan Ekberg. He and Dr. Anders Hedin, a researcher in the department, described the projects now in progress within the group. Using simulation techniques, they are designing and evaluating architectures for high-capacity digital-switching telephone systems. They are also applying their simulation experience to the problem of designing and evaluating man-machine communications within telecommunication systems. This latter activity was not discussed in any detail; Hedin only commented that they are simulating interaction through display terminals relating to call generation and directory inquiries.

In the case of the digital-switching-system design activity, the system being studied is an expanded version of HUGIN, a system originally described by Hedin at the 1976 International Switching Symposium in Kyoto. That system used a high-speed unibus operating at a bit

rate of approximately 130 Mbps, within which 32 standard 30-duplex-channel PCM systems were time-division-multiplexed. Since the standard 30-channel system PCM signal is, itself, time-division-multiplexed, accurate timing control is needed for this second-order time-multiplexed system configuration. The 128 interface modules at the data bus (one for each of the two transmitters and receivers per duplex channel) were activated by a separate control bus. These interface modules used high-speed emitter-coupled-logic (ECL) components.

The new system, called HUGO, which they have recently been simulating, uses HUGIN as a basic module in a hierarchical approach to system expansion. Initially, they considered the possibility of a *third* level of time-division multiplexing, but for the capacity enhancement being considered (a factor of 8), they were apprehensive about the reliability of such a single-threaded system. They were also anxious to limit the operational bit rate on all buses to that level which could be handled by ECL technology. In light of those considerations, they designed a parallel (space-division) multiplexing system to operate with ten interconnecting data buses. (The two extra buses were added to reduce the probability of blocking of data flow between HUGIN modules under conditions of heavy traffic loading for the system.) Their simulation facility is not adequate for handling the full HUGO system, so they have estimated the system's blocking probability through simulations of partial implementations and have had to neglect certain elements in the time-slot assignment algorithm on the buses. That situation leaves this particular project in a status wherein further progress may only be expected through an experimental phase to prove their simulation-based conclusions. Whether that would happen or not was not known at the time of our discussion. (Philip Fire)

ECONOMICS

THE ECONOMIC RESEARCH INSTITUTE IN PRAGUE

The Economic Research Institute of the Czechoslovak Academy of Sciences is located at No. 7, Politických Vězňů (the name of the street translates literally to "Political Prisoners"), just one block from Wenceslaus Square, which is the center of Prague. Started in 1953 as a "cabinet for economic research," it was broadened the following year to a research institute and has now grown to a total of about 250 people. Some two-thirds of these people are professionals, which means, as often happens in socialist countries, that the ratio of professionals to support personnel is extremely high; and so the professionals frequently perform their own clerical chores, a source of some irritation to many of them.

One of many economic research institutes in Czechoslovakia, it constitutes only about 7% of the total national effort in economic research in government-sponsored institutes. It is the only one which is a part of the Academy of Sciences, and the only one which is specifically charged to do basic research. Thus, while there is a little applied research work going on, in general people at this institute work with other institutes which apply their results. For example, the planning committee, which is a ministry at the heart of the government of the country, has its own economic research institute which uses the results of the academy's institute. Again, while this institute builds long-range econometric models, its researchers are more interested in how such models are built and how they are manipulated than in actually feeding the output of such models to the organs of government which do planning for the national economy. Nevertheless, this is the most prestigious of the economic research institutes and has perhaps the highest caliber of research personnel, and so its counsels are respected and the results of its research are used in decision-making at high levels of government.

The director of the institute, K. Roubal, and the vice-director, D. Soural, are both distinguished economists in their own right, although naturally, holding such high positions in a socialist country, they are also members of the Communist Party. Soural told me that the basic question facing the institute is the development of the Czechoslovak economy, and that in planning its efforts the institute takes two points into account: the development of economic theory, and the production of utilizable results for the central organs of the government. At the present time the next 5-year plan is being prepared and intensive discussions are going on between the various economic research institutes on the one hand and the central political planning committee and other central organs of the government on the other.

One of the most important of these topics of discussion is the rate of growth of the Czechoslovak economy. Soural asserted that his institute believes this rate is determined by the energy barrier, while there tends to be a feeling among the central organs of government

that the economy can be expanded more rapidly. As in all other countries, if one is to do something about the energy barrier, one must either lower energy consumption or enlarge energy production. In Czechoslovakia, the latter means either utilizing nuclear power, with all of its problems, or increasing the production of coal, of which there remain vast resources in Bohemia. (Bohemia, which includes the central, northern, and western parts of the country as well as the capital, Prague, is one of the three major divisions of Czechoslovakia, the other two being Moravia in the south and Slovakia in the east.) However, it is very expensive to enlarge the coal production and there are many ecological problems.

The institute is apparently unable to avoid becoming involved in ecological problems. Soural told me of a catastrophe which is now occurring in the northern forests and which is affecting planning at a national level. These forests are being devastated by a beetle, apparently because the forests have become badly weakened by pollution. This pollution arises partly in Czechoslovakia, but mainly in East Germany and Poland.

The work of the institute is divided among several departments and laboratories. There are, for example, two groups working on relations with nonsocialist countries, one with the developed countries, the other with the developing nations. I talked to representatives of three other departments.

The Economic Laboratory, headed by G. Bouška, is divided into two groups, one on operational research, headed by Jaromir Veprek, and the other on analysis and modeling of macroeconomic systems, headed by Martin Cerny. Both of these groups claim to be working on problems of systems analysis, using graph theory as a principal mathematical tool, together, of course, with econometric methods. More specifically, the systems analysis is divided into four stages: (1) formulation of the problem, (2) identification (which depends on the formulation), (3) analysis of structures (utilizing graph theory), and (4) interpretation and implementation of the analysis of the structure. These techniques are being applied to a master model of the Czechoslovak economy, consisting of more than 20 submodels, most of which are either input/output or linear programming models, although there are some nonlinear models. One of these submodels is on foreign trade, one is on investment, one is on labor resources, and so forth. They are working on techniques for aggregating these submodels; in particular, they are looking at the entire model as a graph whose edges are information flows and whose nodes are information transformations, including sources of information and destinations of information as well as models or parts of models.

Černy told me that it is not always easy to tell which are the elements of the graph and which are the connections between elements. Such descriptions are not unique. In particular, they have tried to take into account multiple connections between pairs of elements; for example, between a given pair there may be material flows and information flows, and the information flows may have different qualities and different semantic contents. They find that this type of approach is moderately simple with pure economic problems; they first applied it to a small water-resource system consisting of a single river basin in which they tried to describe the interconnections between the water resources and the utilizations of those resources. They worked at that time with an applied research institute in Brno (the capital of Moravia). As they anticipated, they are finding that it is enormously more difficult to apply this concept to the management system for the Czechoslovak economy.

In the "Department of the Political Economy of Socialism" (the names of such departments obviously have very little to do with their functions) I talked to Miroslav Hrnčiř (names such as this are extremely difficult for us to pronounce--this one is pronounced exactly as it is spelled, taking into consideration that "č" is pronounced "ch" and "r" is pronounced something between "ch" and "zh" with a bit of rolled "ř" thrown in). According to Hrnčiř, this department works on five problems: the theory of value and its implications for planning; the theory of planning, in which they try to adopt and develop the Soviet school; problems of behavior of enterprises and motivations, especially price; foreign trade relations and the implications for the management system in a socialist economy; and the institutional framework of management, especially relations between the upper level (central planning and the ministries), the medium level (industrial organizations), and the lower level (enterprises). Hrnčiř himself works in the fourth group, on foreign trade. Because Czechoslovakia is a small country, it has a highly "open" economy: at least one-third of its national revenue is in import/export, a fraction very much larger than that of larger countries such as the US or the USSR. About two-thirds of this one-third is with COMECON countries, and the remainder with the West, although it is hard to pin down exactly what these numbers are because

of the difficulty of defining relative prices (there are several different exchange rates between Czechoslovak crowns and, for example, US dollars).

Czechoslovakia is trying to adapt its internal price structure to these external factors and is studying the implications for the management system of this adaptation. People in Hrnčíř's group are trying to find theoretical approaches to explain how external prices intrude on internal decision criteria. It is understood that macrodecisions cannot be made without noting external affairs. For example, since Czechoslovakia is a manufacturing country, it was badly hit in the 1970s by the worldwide increases in the prices of raw materials. Hrnčir and others in his group are developing proposals for the adaptation of the management system to needs for the development of the economy, working with the "Department of Economic Growth and the Prognosis of the Czechoslovak Economy."

I spoke to Jan Klacek of the last-named group, who assured me they were essentially a traditionally oriented group interested especially in forecasting, and that they were using largely econometric models, inasmuch as Klacek asserted that forecasting models are either econometric models or naive. Up to now, they have used only partial models of such aspects as foreign trade, investment processes, and consumption, and these have mostly been regression models, basically linear but with some nonlinear aspects. They have been working particularly with a "transcendental logarithmic production function," a new type of function developed in the United States in recent years, which does not require so many side assumptions (such as constant elasticities). Klacek and a co-worker, Alena Nešporova, have been developing new econometric methods for estimating parameters and, in particular, the application of quadratic programming methods to minimize the sum of the squares of the errors in estimation.

Each of the people mentioned above has at least the Candidate of Science degree, which is perhaps equivalent to the American PhD, perhaps a bit lower; and some of them have the Doctor of Science degree, which is a considerably higher degree than our PhD. Most of these have been awarded in Prague. The older workers such as Vepřek obtained their degrees from the Technical University of Prague or the Charles University; the younger workers such as Klacek and Hrnčíř obtained the degree from the academy itself. This institute is very much like an academic institution. Its ranks--scientist, independent scientist, and leading scientist--correspond very closely to the ranks of assistant professor, associate professor, and professor respectively (the next ranks above leading scientist are corresponding member of the Academy and member of the Academy). Many members of the institute, including Vepřek and Černy of those mentioned above, regularly direct doctoral theses.

The members of this economic institute seem to number among them several distinguished scientists who are producing excellent research. This research, however, is published almost exclusively in the Czech language (with English abstracts). Unlike the period through the 1960s, when the best people frequently went to the US or Western Europe for postgraduate study or other work, they are almost always required now to go to the Soviet Union. In general, the interaction of such groups as this economic institute with the West is minimal and shows no sign of increasing. (Robert E. Machol)

ENGINEERING

ACOUSTICS AT THE TECHNICAL UNIVERSITY OF DENMARK

The Technical University of Denmark (TUD) is situated on a large modern campus in Lyngby, just outside Copenhagen. The campus was built in the 1960s and accommodates some 4,000 students of whom about 1,500 are in the Electrical Engineering Department. It takes on the average about 5½ years for a student to graduate with the equivalent of an MSc. PhDs are rare, there being about 20 who graduate every year from the university as a whole after a further 3 years of work. There has been a drop in the number of PhD students since the 1960s; there are fewer scholarships and even though Denmark is a welfare state (unemployment benefits are 90% of the recipient's previous salary) there is pressure to finish, perhaps as a result of Denmark's economic position which is most precarious, with the interest payments on debts alone strangling the country.

Prof. Dr. Leif Bjørnø, professor of of electroacoustics and head of the Laboratory of Acoustics, is well known both in Denmark and abroad as an acoustician. He has been active within NATO's underwater acoustic research, and organized last summer's (1980) well-attended "NATO Advanced Study Institute on Underwater Acoustics and Signal Processing." In Denmark, he is involved with various organizations. He is chairman of the "Research in Industry" (Erkverus Forsker) program which awards Ministry of Education

scholarships to enable people in industry to earn a PhD while working fulltime on a company-approved project. It then takes about 2½ years to defend a thesis and earn a PhD. During that time payment of salaries is shared equally by the company and the scholarship program. The technical output from the work belongs to the company, as do the reports written every 6 months by the PhD candidate. Professors throughout the country give their time free to this program, it being an honor to be asked. Bjørnø has 2 such students at this time. One is studying water pollution control and attempts to sink waste particles by adding a critical, correct amount of enzymes. The other is working on a company proprietary project involving the velocity measurements of the flow of blood.

Bjørnø has long been interested in parametric acoustic arrays. These devices use the nonlinear properties of water at high intensity acoustic power. Two frequencies are transmitted with high power from the same aperture. Mixing takes place in the near field of the aperture where a low frequency (the difference frequency) is generated. The low frequency is transmitted and characterized by narrow beamwidth (due to end-fire effects) and low sidelobes. Bjørnø has been studying these devices for use in shallow water where the radiation directivity helps avoid the generation of multiple modes and thereby improve communications. At this time one of Bjørnø's staff is working in this area and a shallow-water simulation tank is available, 12 m long, 1.6 m wide and 15 cm deep, with various bottoms and the possibility to make waves or produce stratified layers in the water.

Other nonlinear underwater acoustic problems are studied theoretically. Further, a new research group has just been started to study gas explosions which give rise to nonlinear acoustics in air. This work is being done in conjunction with an EEC (European Economic Community) study group on nuclear safety.

Bjørnø and his staff are very involved in the medical application of acoustics. One of his PhD students, in cooperation with the Pharmaceutical University of Copenhagen, is trying to develop a gelatinelike material that simulates human body tissue and that can be used to calibrate ultrasonic probes. One such probe, developed by Bjørnø's laboratory, uses a single transducer in a transmit-receive acoustic system with short pulses at 1-10 MHz. The transducer is only ½ mm in diameter. The aim is to characterize and recognize tissue. The transducer was developed as one of a whole series going up to 15 cm in diameter. Tissue absorption is measured *in vivo* with a transducer being introduced into different organs through a hypodermic needle.

Some of the early biomedical work at TUD was described a little over 3 years ago by Martin Lessen in *ESN* 31-7:275 (1977) and the deleterious effects of acoustic power in destroying tissue were noted. Since then, this has been turned into an asset by using the cavitation zone to break down blood clots or kidney stones and then suck the debris out through the syringe. It takes about 1 minute for a blood clot to disintegrate. This work is being carried out in collaboration with the medical school and is being tackled in different ways. One such scheme operates at 26 KHz. It has a 1-mm-diameter tube, surrounded by a light pipe and viewing glass fibers so that it becomes possible to observe the process visually.

In another medical application being studied with the Biomedical Institute, a transducer moves along the skin surface where good contact is obtained with a cream, in an effort to look for anomalies pointing to skin cancer.

One of the difficulties in transducer design is to find suitable backing materials. Bjørnø is characterizing materials, air, powders, epoxy, etc., and will produce a handbook. The transducer development work is supported by both the Biomedical Institute and the well-known Danish instrument company, Brüel & Kjaer. Material for his transducers comes to a great extent from the Danish firm Ferroperm.

Bjørnø's many efforts, especially his biomedical work, are impressive. I am sure he will prevail in spite of Denmark's economic difficulties. I wish him the very best of success. (T.C. Cheston)

WARSAW--10TH EUROPEAN MICROWAVE CONFERENCE

The 10th European Microwave Conference was held in Warsaw, Sept. 8-12, 1980. It was an interesting time to be in Warsaw, just after the Polish trade unions had achieved major objectives in obtaining independent and powerful rights. The matter was by no means finished; as this article was being written, there were still sporadic strikes as well as general warnings against excessive changes. At the time of my visit, the political happenings were clearly upmost in people's mind and were freely discussed.

Warsaw itself was almost entirely demolished during WWII and has been rebuilt on the rubble of the old city into a grey town. Prices are high, at least for Westerners using the official exchange rate of Zl 30 (30 zlotys) to the dollar (and turning down, as I did to a taxidriver, offers of Zl 110). The export-import of hard currency is strictly regulated and at the time of my visit Westerners were allowed to purchase virtually no articles that could be taken out of the country, with the exception of items available in special, expensive, hard-currency shops.

The meeting was well attended, (I counted about 500 people at the opening ceremonies) and there were many papers from Eastern Europe.

The (4th) Microwave Prize, for the best paper, was presented in the closing session by the technical program chairman, Prof. A. Sowinski from the Industrial Institute of Electronics in Warsaw, to R. Knoechel and A. Schlegel (Technische Universität Braunschweig, FRG). The paper, "Octave-Band Double-Balanced Integrated Finline Mixers at MM-Wavelengths," described various finline mixer circuits and reports up to 2 octaves of bandwidth (10-40 GHz, i.e. 3 cms to 8 mms), a conversion loss of 7 dB and a noise figure of 7-8 dB.

About half the talks concerned solid-state devices. Several of the authors, even some of those who had been invited to present papers, and including one from the US, did not show up, apparently without informing the program chairman in time. (Similar regrettable occurrences were also noted at the URSI [Union Radio Scientifique Internationale] meeting in Munich two weeks earlier.) he fortunate result of this was that the sessions were a little less rushed and there was ample time for questions.

The program contained a total of 122 papers and 23 poster sessions. The former were divided into 9 invited papers, 34 papers on solid-state devices, 31 on passive components, 21 on antennas, 11 on measurements, 6 on communication, and 5 each on remote sensing and industrial applications. Two parallel sessions accommodated all except the invited papers, which were mainly directed at reviewing the state of the art, attracting a large audience.

One of the invited papers discussed the generation of very high power levels at millimeter wavelengths with a relatively new device, the gyrotron. The paper, "The Gyrotrons--High-Power Sources at Millimeters and Submillimeter Wavelengths," was presented by A.L. Goldenberg (Academy of Sciences, USSR). Goldenberg described the gyrotron as a high-power device, being developed in both the USSR and the USA, that uses the interaction with electron bunching in a several-wavelength-long cavity. He suggested that at 3 mms power levels of 10 MW peak for long pulses and 1 MW for CW should be reasonably achievable although at this time less than 1/3 of that has been realized. He showed a table of typical results with 30 to 35% efficiency, up to 1 MW peak powers and up to some 20 KW CW. One example had 68% efficiency at 9 mm giving 1.5 KW CW. (At the 4th Microwave Power Tube Conference held in Monterey, CA in May 1980, Dr. H. Jory from Varian reported a 41% efficient gyrotron giving 212 KW of CW power at 1 cm.)

Another invited paper, "Low Noise MM Wave Receivers," reviewed coherent low-noise receivers for frequencies above 20 GHz. The paper was given by E.L. Kollberg (Chalmers Univ. of Technology, Sweden). He discussed Schottky barrier diode mixers in some detail, both at room temperature and cooled, as well as subharmonically pumped mixers. He then described Josephson-effect mixers, liquid helium cooled to 4K as well as SIS mixers (superconductor-insulator-superconductor) which were thought to look promising for future ultra-low-noise receivers at frequencies up to a few hundred GHz. For frequencies below about 40 GHz, liquid-cooled masers as used in radio astronomy, still give lowest noise (≲10K) as well as substantial gain (≳30 dB).

Measurement of the moisture content of wet material aroused much interest and was treated in one invited paper, three submitted papers, and one poster session, as well as a panel discussion. This measurement is of interest in industrial plants for both nonhydroscopic materials such as sand and coal and hydroscopic materials, usually of organic origin, such as tobacco, potato chips, or sugar beet pulp. With the organic materials the moisture content is an important parameter in storage and processing. There is considerable activity in the subject at the Polish Academy of Science and in his invited paper, "Microwave Aquametry," A. Kraszewski, of that organization, suggested the name *aquametry* to denote the measurement of moisture content. The complex transmission and/or reflection coefficient or equivalent impedances are obtained from propagation measurements through samples, from reflection measurements, or with resonant structures. These measurements are then related to the actual moisture content by calibration. Kraszewski spoke about moisture meters that had been

successfully applied for continuous on-line monitoring. The calibration is sensitive to the material density which could be measured separately, for example, with a nuclear radiation meter. Other methods exist which avoid the density measurement, by using other parameters such as measurements with two widely separated frequencies. In a paper, "Density Independent Moisture Meter at X-Band," W. Meyer, from Philips GmbH, Hamburg, FRG, described their density independent moisture determinations. The paper was coauthored by R. Jacobsen, and B. Schrage. These researchers found that the quantity $A(\phi) = \frac{\varepsilon' - 1}{\varepsilon''}$ was related to the moisture content in a density independent way, ε' and ε'' are real and imaginary components of the dielectric constant). Further, they found that $A(\phi)$ was fairly insensitive to variations in temperature. ε' and ε'' were derived in various ways, for example, from the measurement of the complex transmission coefficient of a sample introduced between two waveguide horns or by the introduction of samples on a planar microstrip line. Overall accuracies were $\pm\frac{1}{2}\%$.

A panel discussion on industrial and biological applications latched onto the subject of moisture measurement, or perhaps more precisely, on the marketing problems of instruments performing that function. The difficulty lay in the fact that every installation required moisture measurements sufficiently different that substantial modifications to any existing instrument would usually be required. It seemed that Philips was not prepared to do this, nor was it willing to market an instrument without reasonable certainty of being able to find a fair sales volume, whereas the Polish team under Kraszewski was willing to go through the painful individual modification gambit. All panel members agreed on the need first to convince and then train the normal plant personnel respectively of the usefulness and in the use of the instrument.

An instrument for finding avalanche victims has been developed by the University of Grenoble in France, appropriately located at the foot of the Alps. M. Bouthinon described the device in a paper, "Passive Microwave Transposer, Frequency Doubler For Detecting the Avalanche Victims," coauthored by J. Gavan and F. Zadworthy. The device is a small transponder that can be built into ski boots or carried in clothing. Detection depth is more than 2.5 m. The suggestion was made that 4 transponders be carried by each person at an expected cost (assuming large production quantities) of about $10 each. Questions brought out some doubt as to whether such costs would not be prohibitive, especially in view of the normally low expectancy of requiring such a device.

An interesting paper, "A Complete GTD Analysis of Rim-Loaded Cassegrain Antennas," describing an improvement to cassegrain antennas was given by G. DiMassa from the University of Naples. The paper was coauthored by C. Savarese from the Naval College in Naples. Both the subreflector and the main reflector of the antenna had dielectric loading on the rim and performance was calculated by means of GTD (geometric theory of diffraction); improvements in sidelobe performance, especially cross-polarized, were noted. Experimental results had been obtained, but these were not given. They are contained in a report to ESA (European Space Agency).

Multifeed antenna systems for telecommunication or TV satellites were discussed in two papers. The first, coauthored by P. Neyret, "The Application of Single Reflector Multifeed Antennas to Direct TV Satellites," was presented by B. Vidal Saint Andre from Thomson-CSF in France. The advantages claimed with such systems were flexibility, low cross-polarization, high efficiency, easy implementation, and rugged wideband performance. In effect, each feed corresponds to a beam and combining the feeds with a weighting network correspondingly combines the radiation patterns to fit the required footprint. The fringe-coverage area is given in the example as requiring a square pattern. The second paper, "A European Contoured Beam Reflector Antenna Development," addressed a somewhat similar development. The paper which described work sponsored by ESA, was coauthored by N. Adatia and B. Claydon from England, P. Balling from Denmark, P. Ingvarson from Sweden, and A. Roederer (who delivered the paper) from Holland. Again, a multifeed system was combined to produce a multibeam cluster in a feasibility model, giving it a contoured beam to cover Europe from a geostationary satellite. The feed cluster for European coverage consists of 25 elements in a hexagonal grid.

Feeds for reflectors with short foci require a wide radiation pattern to properly illuminate the whole reflector surface. A corrugated feedhorn of that type was described in a paper written by two Italian authors, E. Pagana and P. Massaglia, and presented by the former, "Experimental Analysis of Corrugated Conical Horns with very Wide Flare Angles." Corrugated horns were tested with flare angles of up 260°. It was found that widest radiation patterns were achieved with flare angles of about 180°, giving a beamwidth of about 70° at -3 dB, 150° at -10 dB and 140° at -15 dB. Good axial symmetry was

found to exist (i.e. similar E and H plane patterns) with low cross-polarization

Three papers from the Technical High School (Polytechnique) of Lausanne, in Switzerland, were delivered by J.C.E. Besson. The first paper, "TE_{11} Reflection of Open-Ended Circular Waveguides," which was coauthored by S. Mamane and F.E. Gardiol, discussed the use of a flanged waveguide mouth for the nondestructive determination of the dielectric properties of tissue in biomedical applications. The waveguide is placed right against the tissue which is very lossy so that only the field in the immediate vicinity of the interface is of relevance. The study, which was theoretical, came up against considerable difficulties and required numerical calculations of high complexity. (Besson had previously published similar investigations in which an open-ended coaxial transmission line had been used as a probe, and in which the first measurements had shown good agreement with numerical results.) The second paper, "Soil Moisture Determination: Experiments with Passive Radiometers," was authored by P. Neylan, C. Morzier, and R. Caloz from Lausanne and E. Schanda and Ch. Natzler from the University of Berne. They found an experimental relationship between emissivity and soil moisture content, particularly for middle-heavy and light soil; however, they also found a strong dependence of surface roughness and interfering effects of vegetation cover. The third paper concerned current distributions on microstrip radiators.

A very clever and ingenious antenna was described by workers from Thompson CSF in France, in a paper titled "The Prismatic Array Antenna, a Nondisbursive Traveling Wave Array Antenna," written by S. Drabowitch and M. Dudome and presented by the latter. The antenna uses an end-fed waveguide feed-array (e.g. with slots or dipoles) which gives a beam that squints at some angle off broadside. The squint angle is a function of the element spacing in terms of wavelength and is therefore frequency dependent. The radiation from the waveguide is contained between parallel plates and is intercepted at some angle by what amounts to a lens formed by an array of a combination of receiving horns, phase-shifters and transmitting horns. The phase-shifters give substantially frequency independent phase-shift and are arranged in such a way that a beam comes off at broadside to the exit aperture. The frequency independent phase-shift causes the radiated beam to be scanned as a function of frequency. The various constants were chosen such that this scan cancels that scanning which is due to the end-fed feed-array. A substantially frequency independent beam-pointing system was obtained by this method. In this writer's opinion there are simpler methods of obtaining beams from line sources that do not scan with frequency and that have less complex hardware requirements; this compensation method, interesting and ingenious as it is, is not likely to find a cost-effective practical application.

The conference covered many subjects and achieved broad participation from all over Europe. Regrettably, many of the presentations had viewgraphs that were so cramped with illegible handwritten equations and information as to become indigestible. They also tempted the speaker to become an equation reader. It seems universally difficult to get speakers to present ideas in their talks, relegating equations to the written text or its appendix. If that can ever be achieved, perhaps it also will eliminate some of the papers that show admirable skill in solving very difficult but regrettably unimportant problems. (T.C. Cheston)

ENVIRONMENT

ENVIRONMENTAL PROTECTION STUDIES IN SOUTHERN FRANCE

Le Centre d'Etudes Techniques de l'Equipment d'Aix-en-Province is one of six regional centers in France which combine some of the activities that in the US are performed by the Army Corps of Engineers, the Environmental Protection Agency, and the Department of Transport. The center in Aix-en-Provence is the largest, with 650 employees. These centers are jointly administered by the Ministry of Environment and Quality of Life and the Ministry of Transport. They were originally set up to handle engineering and other problems associated with the postwar explosion in highway construction and this is still their primary occupation. However, they have branched out into many other fields including land management and urban planning, urban and interurban traffic control, highway safety, public hygiene, harbors and waterways, information and management systems, management of economics and finance, architecture, and all types of civil engineering, and protection of the environment. Research, design, and management studies are made for governmental bodies at all levels as well as for private companies and individuals.

This article is concerned with environmental studies. One subject of interest to me after 22 months in noisy London is traffic acoustics. Noise levels associated with traffic come under serious

consideration at the center. Acoustics are taken into account in the design and placement of highways and in the materials used in them. Architects of proposed apartment houses and office buildings that are to be built close to busy highways may come to the centers to receive concrete advice on how to sound-insulate to keep traffic noise at an acceptable level within the structures. Center employees monitor noise levels within the buildings after they have been constructed to determine the effectiveness of their advice.

There are several individuals working on various aspects of marine pollution. Dr. Claudine Valerio and her collaborator, Engineer M. Llebaria (Laboratoire d'Astronomie Spatiale, Marseille) have developed a quantitative multispectral remote-sensing system employing aircraft and cameras to measure rates of mixing and diffusion and movement of pollutants near shore. It is used primarily in the planning for improving sewer outfall systems.

Rhodamine dye is introduced into coastal waters through an existing sewer outfall or at the location where one is proposed. An airplane flies over the area for about 8 hours taking frequent photographs of the dye plume at various stages of the tide. Two cameras are used. Filters are employed so that one camera photographs light at the wavelength of the peak of fluorescence and the other photographs the blue part of the spectrum outside the spectra of the rhodamine. The negatives are digitized on a PDS 1010A microdensitometer of very high accuracy. A computer is then used to calculate the amount of dye in a vertical column extending from the surface down to the bottom of the plume (depth = z) at grid points (100μ × 100μ) on the negatives. The quantity of dye, q(z), is then contoured in g/cm^2. Corrections are made for experimental conditions: the angle from which the light is coming, sea and swell, and turbidity.

Density on negatives is calibrated in terms of illumination and then q(z) in several ways. First the water is sampled at several depths and at several locations in the plume and the dye concentrations are determined in the laboratory with a fluorescence detector. After integrating q(z) with depth the results give the amount of dye where each set of vertical samples was taken. The relative value of illumination is then plotted against this amount. Valerio has developed a theory of fluorescence that links the known total quantity of rhodamine dye in the plume directly to density distribution of the negatives, and contours can be accurately drawn without actual samples. The system is accurate to within 5 percent.

The synoptic contoured picture of the dye distribution resulting from aerial photographs which cannot be obtained in any other way is extremely useful in determining the rate of dispersion of effluents as well as where the plume moves as tidal currents change speed and direction.

The first major study was off Propriano, a resort city on the west coast of Corsica. During summer the population there increases by a factor of 10. Local authorities wanted to know if any effluent from the present sewer outfall approached the local swimming beaches. Local currents were measured by following the paths of floats with sequential air photography, while rhodamin was continuously released through the outfall and photographed from the air.

The study showed that sewage would come into beaches during some phases of the tide and under certain wind conditions. In order to continue to use the present outfall and not pollute the beaches, the sewage would have to be thoroughly treated before discharge.

Another study is underway off Atibes near Nice to locate the distance from shore that would be optimal for a new sewer outfall. First discrete amounts of dye (600 g) were placed in three locations, three times a day and were followed by aircraft photography. A "guessed" best location was selected from these observations, and a continuous source of dye plus floats will be used in a study similar to the Propriano study. The method is now fully operational.

Valerio has studies in progress at several locations on the south coast of France where she is observing the movement of visible effluent from outfalls near high cliffs. She mounts a spectrophotometer on the top of each cliff. The areas around the outfalls are very slowly scanned by optics focused on the spectrophotometer and over the visible and near-infrared part of the spectrum. The color of the waste water is clearly seen through the use of four narrow-band filters. The results of the spectrophotometer studies are used to determine the most useful spectral channels for more detailed aircraft data acquisition in order to obtain photographs with the highest contrast. The aim of these studies is to develop an efficient methodology for inventorying coastal pollution. The spectrophotometer is calibrated with clean water and has a reference beam focused on a white cloth to take into account variations in sunlight.

I also talked with Mme. G. Bicheron, head of the chemistry group at the center. This group is also working on marine pollution research. It is doing a pilot

study on the influence of currents on concentrations of pollutants in a laboratory tank. It is studying the rate of disappearance of several forms of bacteria at the interface where urban sewage meets salt water and the sea. The group is also carrying out a controlled laboratory study of the effects of various concentrations of salt water from 0 to full sea water at various temperatures on several species of bacteria.

It was stated above that the main job of the laboratory is to carry out research on highways. At the time of this writing, a tight money situation had slowed down the rate of new highway construction and enabled the laboratory to divert funds to its study of marine pollution. Some of the increased effort will go into research on thermal pollution from nuclear power plants.

After visiting the center I had time to visit Laboratoire d'Astronomie Spatiale in Marseille, a part of CNES, the Centre National d'Etudes Spatiales. I was given a demonstration of the very elaborate computer system used for manipulating all forms of digital processed imagery such as Valerio's photographs and astronomical photographs. A relatively simple conversational programming system was used that gave a wide range of ways of presenting these data on a screen. Relatively untrained people can use the system. (Wayne V. Burt)

MATERIALS SCIENCE

COMPOSITES, AIRCRAFT, AND LIGHTNING

During the spring of 1980, two meetings concerned with the use of composite materials in aerospace construction were held by the Advisory Group for Aerospace Research and Development (AGARD) of the North Atlantic Treaty Organization (NATO). The first meeting, entitled "Effect of Surface Environment on Composite Materials," was held in Athens from 14 to 17 April. The second, "Electromagnetic Effects of (Carbon) Composite Materials Upon Avionic Systems," took place in Lisbon, from 16 to 19 June. I was able to attend only the Lisbon meeting, but fortunately, Mr. G. Jubé, who had been the chairman of the Athens meeting gave a detailed overview of that meeting during the meeting in Lisbon. In this article I summarize Jubé's talk and review the Lisbon meeting which had to do with the ability of composite material to shield avionics systems from electromagnetic (EM) radiation. Taken together, these two meetings give a fairly comprehensive view of the extent to which composite materials, especially carbon-fiber reinforced plastics (CFRP), are replacing aluminum and titanium alloys in aircraft construction, as well as the problems associated with this replacement. Proceedings of these meetings will be published by NATO (obtainable from the Report Distribution and Storage Unit, NASA Langley Research Center, Hampton, Va. 23661).

It is useful to realize the extent to which composites are being used in both military and civilian aircraft. Therefore, before discussing Jubé's review of the Athens meeting, I would like to describe the talks by his two companion speakers during the first session of the Lisbon meeting: Dr. R.W. Leonard (NASA, Langley Research Center) and Mr. T. Sharples (British Aerospace Aircraft Group, Warton, Preston, UK).

Leonard described the NASA Aircraft Energy Efficiency Program (ACE) which is specifically directed to the introduction of composites into passenger aircraft: the upper/aft rudder on the DC10, the elevators on the Boeing 727, the inboard ailerons on the Lockheed 1011, and the spoilers on the Boeing 737. In each case no more than 20 aircraft are involved and the weight saving is insignificant. The program's purpose is to develop experience and confidence in CFRP for aircraft structures. These tests on the 727 are especially important to Boeing because the company plans to incorporate a substantial amount of composite material (1300 kg) into the 767 which is expected to go into production in 1982. There will be an even larger amount of corporate material in the 757 which is due for production in 1983. The composite materials going into the 767 and 757 will all be secondary structures rather than primary, load-bearing structures.

Composites are already used extensively on military aircraft where weight-saving (and thus payload and/or range) is at a premium. Leonard noted that in the F18, for example, there are over 1,000 pounds (9.9% of the total structural weight) of CFRP, largely in wing, stabilizer, and rudder-skin structure. The AV-8B V/STOL (vertical and short takeoff and landing) comes close to being an "all composite" aircraft. The forward fuselage as well as most of the wing and tail structure is fabricated from CFRP.

Sharples discussed the advantages and disadvantages of CFRP, and explained some of the economic factors. He pointed out that it is more realistic to use composites in lightly-loaded structures, such as the front fuselage section, where significant weight saving can be realized, than in highly-loaded structures such as the root section of a wing. Such structures require complex laminate layups, but achieve only negligible weight savings. Besides the obvious fuel savings

that can be realized by the use of CFRP to reduce aircraft weight, Sharples discussed the lower production and manufacturing costs that are possible when fabrication is done with CFRP instead of metal. Although the manufacturing costs to make a CFRP component are greater than the costs for a metal component, the assembly costs for CFRP are lower. This suggests that the automation of both manufacturing and assembly operations could make the overall manufacturing costs for composite components lower than those for metal components. Sharples estimated that a cost reduction of nearly 20% could be realized if 40% of the aircraft structure were CFRP.

Jubé gave an excellent and concise review of the Athens meeting on the effect of surface environment on composites. The meeting included sessions specifically devoted to the effect of moisture; the combined effect of moisture, heat, and mechanical stress; impact behavior; and the effect of rain erosion and lightning strike. There was also a session which covered the in-service experience in all these areas. According to Jubé both manufacturers and users have expressed concern over moisture absorption by CFRP and glass fiber reinforced plastic (GFRP) and the effect this might have on the mechanical properties of these composites. He added that there is not enough data (especially field experience) to decide whether their concern is warranted. Jube emphasized that there is a need to develop meaningful accelerated aging tests; at present, these tests can only rank different materials. Because of this lack of data and experience, the design engineers are taking a very conservative attitude in assuming large reductions in allowable strength because of moisture uptake. Jubé compared this concern about water absorption by CFRP with the similar concern design engineers had expressed about stress corrosion in metal aircraft.

The question of moisture uptake and loss of strength cannot be separated from the effect of temperature and mechanical stress. Taken together, the three "environments" are expected to be far more dangerous than any of the factors would be individually. It was concluded at the Athens meeting that much more fatigue data is needed; and it was recommended that the tests simulate the cycling of humidity, temperature, and stress during flight.

Another conclusion of the Athens meeting was that while the nature of the damage to composites by high-loading rate (impact) stress cannot be predicted, damage can be lessened by using matrix resins with high elongation to break (high fracture toughness). The participants also agreed that lightning damage (aside from its effect on avionics systems) was not as serious as had been previously thought while admitting that this might depend on the type of strike.

The session on impact damage also dealt with rain erosion, and it was concluded that this erosion was a serious problem about which virtually nothing was known. (See however ONRL Report C-6-79).

About two years ago, there was much concern about the possibility that in the event of the crash and subsequent burning of an aircraft having CFRP components, there might be a release of short, conductive graphite fibers which would short-circuit nearby electrical generating and electronic equipment. This question was very thoroughly investigated in the US, and at the Athens meeting Dr. V. Bell (NASA, Langley, VA) reported the results of a major study which concluded that the degree of risk was low but that the use of char-forming matrix resins, non-conductive coatings for the fibers, or non-graphitic reinforcement would totally remove the risk.

The most revealing part of Jubé's review included his remarks about the in-service experience session. Field reports about aircraft with CFRP components indicate that many of the problems that R&D work indicate would arise if composite materials were used in aircraft have not been realized. Jubé suggested that the introduction of composites into aircraft structures over the past two decades would have been slowed considerably if recent research results that indicated strength reduction because of moisture uptake, poor impact resistance, and low compression strength had been known from the start. On the other hand, Jubé pointed out that the composite components presently in service have been very carefully fabricated. He expressed uncertainty as to what might happen in full production, when there is always a tendency to relax quality control, and questioned whether flaws might not be introduced that would exceed acceptable limits.

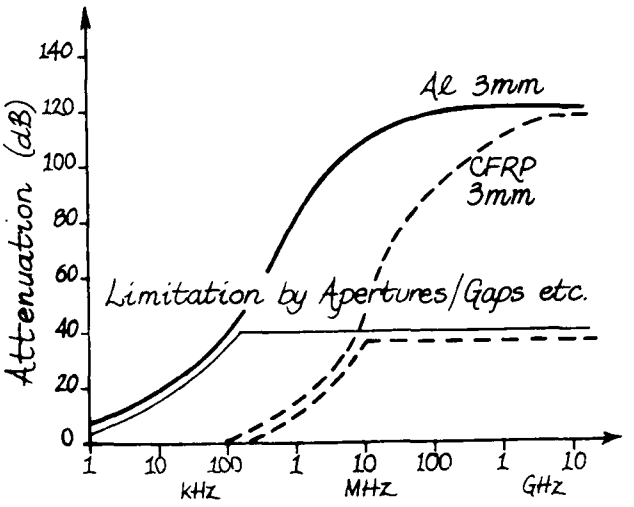
The in-service problems that the aircraft users identified at the Athens meeting related mostly to flaw detection, quality control, and repair. They find ultrasonic detection of flaws cumbersome and believe that the critical flaw size (for crack growth) is poorly defined. They see a need for quality control specifications and for the development of rapid and reliable repair procedures.

I turn now to the discussion about the electromagnetic (EM) effects of composite materials on Avionic systems that took place at the Lisbon meeting. The level of concern at Lisbon was similar to that which Jubé observed at Athens

with regard to mechanical properties. Laboratory data, on the one hand, indicates that CFRP is much less effective in shielding EM fields than is aluminum. On the other hand, engineers from the aircraft manufacturers do not feel that the problem is that severe and believe that in cases where it is found to exist, it can be dealt with. The difference that exists between aluminum and CFRP in shielding capability is issustrated in the figure t taken from the paper by Mr. K.H. Ripple (Messerschmitt-Bolkow-Blohm [MBB] Munich, (FRG). This chart is based on MBB experiments and literature data on the shielding of magnetic fields by CFRP and aluminum (Al). (The magnetic field component is a more serious threat to avionics than the electric component.) Indicated along the abcissa of the figure are the frequencies. This data was taken from a paper presented by R. Wallenberg (Syracuse Research Corporation, Syracuse, NY) at the Lisbon meeting.

There are a number of points to be made about the figure. First of all, the EM threat is largely from low-frequency radiation and is essentially transparent below 100 Hz CFRP. Secondly, above 10 MHz shielding reaches upper limits that are essentially equal for both aluminum and CFRP because of the presence of apertures in the aircraft structure, e.g., windows, seams around hatches, and "leaky" joints. Finally, it should be noted that Al and CFRP are compared in equal thicknesses but in many instances a CFRP panel is thicker than the Al panel it replaces, thus the comparison should be made on the basis of specific modulus or specific strength. In such a comparison the difference between CFRP and Al could be signiricantly reduced. Mr. B.J.C. Burrows (UK Atomic Energy Authority, Abingdon) presented a paper demonstrating that EM shielding by CFRP is very thickness-dependent and predictable from theory. For example, there can be as much as a 5-fold difference between a 3-ply and a 40-ply laminate.

The seriousness of EM radiation to avionics can be judged from calculations that Wallenberg gave in his presentation. He finds that for the relatively low level of on-board radio-frequency radiation (1-100 MHz) the induced power (0.15 W) would disable integrated circuits shielded by 0.25 mm (19 plies) of CFRP. An aluminum enclosure would provide complete shielding. This level of on-board radiation is considerably less than the EM environment on a carrier deck (see figure).



Lightning is by far the most worrisome source of EM radiation: 10^6 W for a direct strike and 10^9 W for nearby lightning. On an aluminum aircraft the high-amplitude, fast-rising pulse of current flows only on the outside skin and neither magnetic flux nor current diffuse to the inside surface in times of interest. Charge dissipation by surface conduction would not be as effective for CFRP because of its high resistance (10^3 times greater than Al) and, according to Burrows this "skin effect" protection is not discernible below 10 MHz. He stated that significant resistive voltage developes in CFRP (100 V/m) which would couple to circuits within the aircraft to generate voltages of similar magnitude. Wallenberg's calculations also indicate lightning strike to be an unacceptable risk. Burrows reports that all diode and transistor base devices as well as integrated circuits would be wiped out by both a direct strike and nearby lightning. On the other hand, his calculations for an Al-skin aircraft indicate that a direct strike could deliver enough power to transmission lines to damage most but not all avionics, while nearby lightning would have no effect.

A direct lightning strike can also inflict mechanical damage on an aircraft, although this was not cited as a major concern in the Athens meeting. In Lisbon, however, there was some discussion that, depending on where the strike occurred, the arcing produced by the strike and

the associated EM radiation could affect the avionics.

The prophecies of disaster because of the poor EM shielding capability of CFRP were not shared by everyone, and especially not by engineers in the aircraft companies. Mr. G.L. Weinstock (McDonnell Aircraft Co., [MCAIR], St. Louis, MO) presented a paper in which he claimed that MCAIR has been able to integrate CFRP with high-performance avionics. According to Weinstock, the integration involves determining the expected EM field and taking appropriate measures such as line filtering, wire and bundle shielding, and balance signal circuitry. Bench testing and simulated fuselage testing have been done at MCAIR and in the simulated fuselage tests EM leakage was dominated by leakage through apertures in both Al and CFRP structures. As for lightning strike, Weinstock stated that it has been demonstrated that CFRP airframe structure has sufficient current-carrying capability to withstand a strike without any avionic damage except in the vicinity of the strike itself. This, he claims, can be eliminated by thin metallic coatings on the CFRP.

Weinstock's point of view was shared by others, notably by G. Barton (Westland Helicopter Ltd, Yeovil, UK), I.E. MacDiarmid (British Aerospace, Warton, UK), and Burrows. As stated earlier, Burrows thinks CFRP is incapable of dissipating lightning strike current by the skin effect. However, he has found that the problem can be solved by applying a thin Al coating on the CFRP. The coating can be very thin since charge transfer is assisted by graphite fibers in or near the surface of the composite.

Another paper in which it was suggested that there were no insurmountable problems with avionics in CFRP structures was presented by Mr. C.L. Blake (Directorate of Avionics Engineering, Wright-Patterson AFB, OH) who reported the results of a working group comprised of specialists from various Air Force organizations and laboratories. Among the conclusions reached by this working group was the need for shielding characterization and standardization; the deficiencies in these areas were repeatedly mentioned throughout the Lisbon meeting.

There was very little comment from the French attendees about the severity of the EM threat. However, Mr. J.C. Alliot (Office National d'Etudes et de Recherches Aerospatiales, [ONERA] Chatillon, France) described a very ambitious program in which a propeller-driven transport has been fitted with equipment for measuring EM-induced transient currents from radio-frequency radiation, skin electrostatic charging, and lightning strike. The program was initiated by Centre d'Essais Aeronautiques de Toulouse (CEAT) when they became convinced that laboratory tests were inadequate to evaluate the EM threat. Now CEAT and ONERA, in a cooperative effort, have completed the installation of equipment on the transport and are in the process of collecting data.

Whatever disagreement may exist about the ability of CFRP to shield out EM radiation, there was general agreement that apertures, especially joints between composite and aluminum or between composite and composite, present very serious problems. A well-bonded adhesive joint can effectively screen external radiation. However, unless there are conductive paths through the joint, electrostatic charge accumulation at the bond line can discharge to produce intense EM radiation. Of more serious concern are the radiation produced when the charge pulse from a lightning strike arcs across the joint, and the resulting ohmic heating which may be severe enough to cause mechanical damage.

The solution that seemed to be favored by most engineers at the meeting was an overlap joint held by a metal bolt and adhesive. The adhesive may be conductive, but it is the bolt that is expected to carry the current. Nevertheless, there are some major problems associated with bolted joints. First of all, good electrical contact between composite bolt and metal produces favorable conditions for electrolytic corrosion because of the electrochemical potential difference between CFRP, aluminum alloys, and titanium bolts. Secondly, drill holes through composites create opportunities for the initiation of interlaminar fatigue cracking from the cut edges of the bolt hole. State-of-the-art composites are especially susceptible to interlaminar cracking because of the low fracture toughness of the matrix resins. Dr. J.A. Birken (US Navy, Washington, DC) discussed the problems associated with conduction through bonded joints and described the bolted lap joint and also the step-scarf joint in which one joining member dovetails into the other. This scarf joint can be designed to provide excellent conductivity and is mechanically much more acceptable than the lap joint. However, the machining of the scarf joint introduces a cost factor which is at present unacceptable to design engineers.

The all-composite aircraft is at least on the technological horizon. Aerospace engineers seem convinced that it is quite feasible to use CFRP in aircraft construction, and that the mechanical or electrical problems that may exist are solvable. As Blake said in his talk, "There are no 'show-stoppers' in sight." In the experience of this writer, this is a quantum jump in attitude from two

years ago when the aircraft industry was very hesitant about composites. However, one cannot help but wonder along with Jube what will happen when CFRP aircraft structures get into full production. (Willard D. Bascom, NRL)

MEDICAL PHYSICS

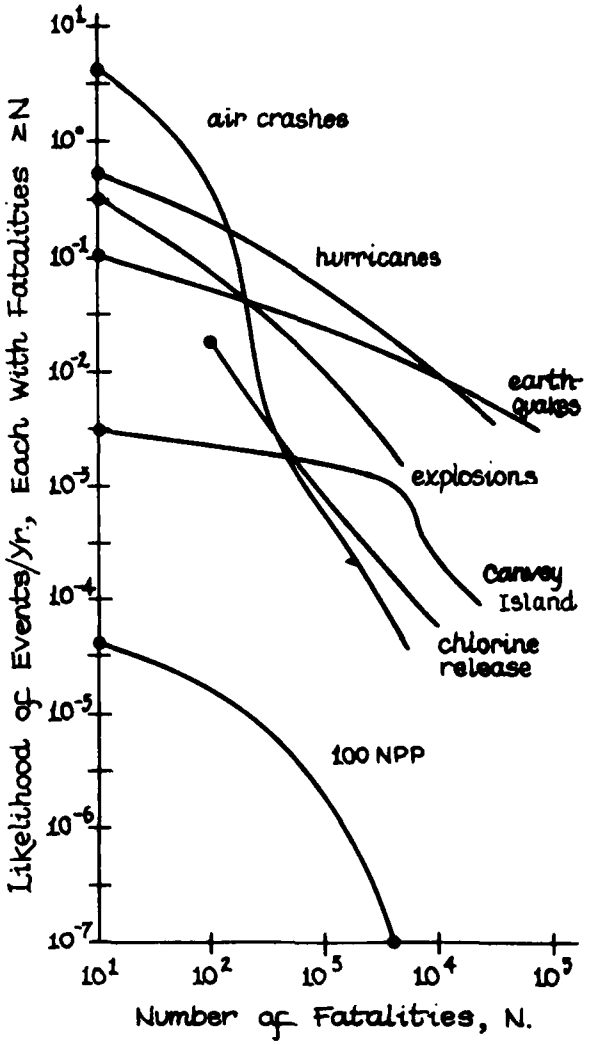
RISK ASSESSMENTS OF DIFFERENT ENERGY SYSTEMS--AN IAEA ANALYSIS IN VIENNA

The city of Vienna combines old-world charm with ultramodern architecture and structures. Clear examples of each are the world famous State Opera (seats are available at $80 per person!) on the one hand, and the new Vienna International Center, north of the Danube River, on the other. The center is a huge complex which provides housing for a number of United Nations agencies. Its completion and use by the United Nations represents a successful bid by Austria to become and remain a major center for international activities and meetings. While Vienna International Center is the official name, it is commonly known to taxi drivers (and everyone else) as UNO.

One of the groups housed at UNO is the International Atomic Energy Agency (IAEA). Earlier this year I had met Dr. John R. Horan at a meeting in Jerusalem of the International Radiation Protection Association. Horan is chief of the Radiological Safety Section, Division of Nuclear Safety and Environmental Protection of the IAEA. His group has been concerned with developing methods to assess the risks associated with various forms of energy. Many writers have made the point that society is not risk free, (e.g. David Okrent in *Science*, vol. 208, 372-375, April 1980: "Comment on Societal Risk"). More specifically, Okrent reminds us that no energy source is free of risk "either to the environment or to the public, including solar energy." Ultimately in democratic societies decisions about energy sources and choices among them are made by duly elected representatives. The contribution that "experts" can make to this process is to provide society with analyses of risks and benefits associated with the choices and options that may be available. It is in this context that the work of Horan and his colleagues is important. Of especial interest is a recently completed study by S.C. Black and F. Niehaus on the "Comparison of Risks and Benefits Among Different Energy Systems." (*Proceedings of the International Workshop on "Energy/Climate Interactions,"* Munster, March 1980; W. Bach J. Panrath, J. Williams [eds]; Reidel Publishing Co, Dordrecht, Boston.)

A first step in performing a risk study is to obtain the technical data which describe the risks resulting from the use of a technology. Such data include: the events which may occur (accidents, emissions, etc.) and their likelihood of occurrence, the consequences of the events (property damage, injuries to persons), the distribution of consequences in the affected population, and uncertainties in these estimates.

While these technical data are largely "objective," judgmental aspects are inevitably introduced by the technical experts, and to some extent the evaluation process is also subjective.



NPP DATA FROM WASH-1400(NUREG-75/014), WASH, D.C.

CANVEY ISLAND STUDY: 1978, HEALTH & SAFETY EXECUTIVE, LONDON (ISBN 0 11 883203 4)

Fig. 1.

Black and Niehaus present a number of different methods to evaluate what is an acceptable level of risk. One approach is to put the risk into a context of what society already experiences or is subjected to in a natural environment. Examples of the former are air crashes, explosions of various kinds, and accidental releases of noxious chemical fumes (e.g. chlorine). In the latter category one may mention hurricanes and earthquakes. The authors make a comparison of these kinds of risks with those to be expected from nuclear power plants in the US and for the petrochemical facilities installed on Canvey Island in the UK. The risks for these latter two types were estimated using event- and fault-tree analyses.

Figure 1 is a graph of the probability in events/year with consequences ≥N as ordinate, versus the number of fatalities, N.

At the level of N=100 fatalities, air crashes show the highest risk followed by hurricanes, explosions, and earthquakes. The risk from Canvey Island is a couple of orders of magnitude lower at values of N between 10 and 100. However, for larger accidents Canvey Island reaches the same range of risks as air crashes, hurricanes, etc. The risk of 100 nuclear power plants (NPP) located in the US at current sites is estimated to be two to four orders of magnitude lower then the other risks portrayed in the graph.

A second method of evaluation, once it has been shown that the risk of a technology is in line with other risks, is to consider the relative benefits provided to society, based on a normalization of the risks of the technologies that are being compared. In their study, the authors chose five alternative methods of producing electricity, and then determined the relative risks in terms of the accidental injuries, the accidental deaths, and the estimated incidence of fatal disease as a consequence of producing 1GW(e) (gigawatt-electrical = 10 watt-electrical). The risks were determined separately for an occupational category and for the public. The five technologies studied are coal, oil, gas, LWR (LWR = light water reactor-nuclear) and solar thermal.

Coal: The analysis is based on 1975 US data where 55% of the coal was produced in surface mines and 45% by deep mining. The coal is transported, on the average, for a distance of 500 km: 66% by rail, 21% by truck, and 13% by barge. The plant is assumed to operate with a 38% efficiency. The flue gas desulfurization is considered to be equivalent to 0.5% sulfur content in the coal. Public health effects are based on an assumed stack height of 305 m, and a population of 2.2 million persons within a distance of 80 km.

Oil: Sulfur content is assumed to be 0.2%. Tanker transportation is assumed.

Gas: SO_x emissions are assumed to be 24 t/GW(e). This number may be compared with 31,000 t/GW(e) estimated for coal with 0.5% sulfur.

LWR: A light water reactor with 33% efficiency is assumed. Health effects of storage of nuclear waste are assumed to be zero. No credit was given for recovered plutonium.

STEC: (Solar thermal electric conversion systems): 100 MW(e) plants were considered with 6 hr rock and oil storage operating at a 54% capacity factor. Thus 18.5 plants are needed to supply 1 GW(e) [(100 MW(e) x 0.54 x 18.5 = 1 GW(e)] Favorable conditions in the southwestern desert in the US are assumed with an a annual insolation of 8 kWh/m^2 x day. Each 100 MW(e) plant has 28,600 heliostats with surfaces of 30.4m^2. Each plant covers 3.5 km^2 of land.

All five plants are assumed to have lifetimes of 30 years. All the computed data have been normalized for the production of 1 GW(e). Tables 1 and 2 list the results for occupational and public effects. Results are given for various steps of the fuel cycle, including fuel supply, transportation, normal operation and construction. The most important contributing step(s) is(are) listed for each energy type. However the numbers are combined for convenience. Literature values are listed for comparison.

Coal: In Table 1, (p. 523) one notes the reduction in occupational fatal diseases for coal in the present study as compared to earlier ones. This may be a consequence of the improvements resulting from adoption of the provisions of the US Health and Safety Act of 1969. The authors make the point that there are radioactive emissions from coal-fired plants. They estimate the emissions to be of the same order of magnitude as those from pressurized water reactors. However the magnitude of the radioactive emissions from coal-fired plants depends importantly on the source of the coal. This effect is not included in the study. The risks of climatic changes caused by CO_2 emissions from combustion of fossil fuels have not yet been quantified and were not included.

Oil: The occupational deaths are based on studies of Norwegian offshore drilling activities in the North Sea. It does not reflect the recent accident in the upset of a North Sea rig which resulted in the loss of a few hundred lives.

TABLE 1

Occupational Health Effects from Supply of 1 GW(e)

	Accidental Injuries (in MDL)		Accidental Deaths		Fatal Diseases	
	This Study	Literature	This Study	Lit.	This Study	Lit.
COAL Fuel Supply	4200-4400	1660-14000	1.1-1.2	0.5-6.2	0.10	
OIL Fuel Supply	3400	500-7500	0.52	0.08-3.6		
GAS Fuel Supply	2200	300-3500	0.30	0.07-0.5		
LWR Construction, Fuel&Reprocessing	600	200-1400	0.17	0.09-0.6	0.42-0.49	0.03-0.92
SOLAR/THERMAL Construction & Normal Operation	8400	10,300-22,300	2.1	6.4		

TABLE 2

Public Health Effects from Supply of 1 GW(e)

	Accidental Injuries (in MDL*)		Accidental Deaths		Fatal Diseases	
	This Study	Literature	This Study	Lit.	This Study	Lit.
COAL Transportation	600-700	60-800	0.6-1.4	0.2-1.9	3.2-22	1.4-150
OIL Transportation	2				1.1-7.5	0.8-140
GAS Fuel Supply and Transportation	2800		0.35		0.005-0.036	
LWR Transportation	6	8	0.004	0.009	0.27-0.32	0.014-0.36
SOLAR/THERMAL Transportation	77	112	0.03-0.08	0.6-1.4	0.07-0.47	0.02-0.03

*MDL = Man Days Lost

Gas: The occupational risks of gas supply from the North Sea would be higher (by a factor of five) than listed in the table. The risk of destroying population groups by gas clouds from LNG (liquid natural gas) tanks has not been estimated, and is not included.

LWR: Health effects are based on an assumed risk factor of $2 \times 10^{-4} \frac{1}{\text{man-rem}}$, which includes cancers plus genetic effects for all generations.

Solar Thermal: Calculations are based on optimistic estimates. New calculations indicate higher risks for construction of any energy system.

The data from Tables 1 and 2 permit a ranking for the various effects. However the nature of the risks are quite dissimilar. One way to compare injuries (expressed as MDL = man days lost) with fatalities is to make some assumption of an assumed number of MDL for each fatality. A number that has been used is one fatality to be deemed equivalent to 6,000 lost man days (200 working days per year x30 years). On this basis the data of Tables 1 and 2 can be ordered for purposes of comparison. This is done in Table 3. On this basis one notes that for occupational groups the largest numbers are associated with solar thermal followed by coal. Oil comes next, and the last two, gas and LWR, are comparable. For public risks the largest numbers are associated with coal, followed by oil. The remaining three may be argued to be in a similar "ballpark." The basic reason for the risk to the public from coal and oil stems from the assumed sulfur content.

Comparing risks in the manner done by the authors allows for consideration of technical options in terms of their effects on society. However the authors are quick to point out the large uncertainties involved in many of the estimates. What is interesting here are not any particular numbers, or even an apparent ranking, but rather the idea of making risk assessments based on past experiences and on reasonable extrapolations. This appears to be a better way than the assumption made in many public discussions that "x" is an unsafe source of energy, and should by replaced by "y." (Moses A. Greenfield)

TABLE 3

	Accidental Injuries	Accidental Deaths	Fatal Diseases
Occupational Risk			
COAL	4300	6,900	6,000
OIL	3400	3,100	
GAS	2200	1,800	
LWR	600	1,000	2,700
SOLAR/THERMAL	8400	12,600	
Public Risk			
COAL	650	6,000	19,200 to 132,000
OIL	2	-	6,600 to 45,000
GAS	2800	2,100	30 to 220
LWR	6	24	1800
SOLAR/THERMAL	77	330	420 to 2,800

Occupational and Public Risk Expressed as Man Days Lost per GW(e) for Listed Energy Systems

PUBLIC BELIEFS ABOUT FIVE ENERGY SYSTEMS--A STUDY IN AUSTRIA

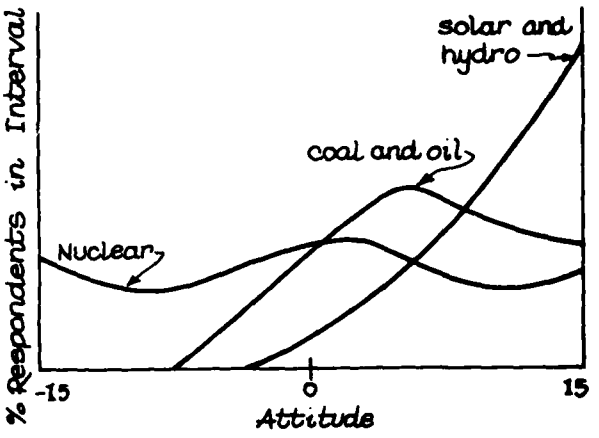
In a recent visit to the IAEA (International Atomic Energy Agency) in Vienna, I became aware of joint studies made by the agency with other international bodies, in particular, the International Institute for Applied Systems Analysis (IIASA). IIASA is a nongovernmental, multidisciplinary, international research institution founded in 1972 by scientific institutes from 12 countries from both East and West. The goal of IIASA is to bring together scientists from a variety of countries to work on problems of common scientific interest. The membership has currently increased to 17 national member organizations from the Soviet Union, Canada, Czechoslovakia, France, East Germany, Japan, West Germany, Bulgaria, US, Italy, Poland, UK, Austria, Hungary, Sweden, Finland, and the Netherlands. For a detailed account of its mode of operation see *ESN* 34-6:304 (1980).

A problem area of common concern to the IAEA and IIASA has been the view taken of nuclear energy by the public in various countries. The matter of public acceptance is an increasingly important constraint to be considered and taken into account by policy makers and decision makers in all countries, as far as nuclear energy is concerned. In a report on risk assessment (*ESN* 34-11:521 [1980]) there is a description of a study on risk assessment of five energy sources (coal, oil, gas, LWR (nuclear power) and solar thermal) made by a group in the IAEA. In contrast this report presents the major findings of a study of public beliefs about five energy systems, which includes four of the five systems studied by the IAEA. The IIASA study includes coal, oil, hydro, nuclear and solar. Thus the latter study has hydro instead of the gas in the IAEA study. What is of interest, in addition to the findings of the IIASA study, is to compare public beliefs about energy systems with an analysis of risk assessments of virtually the same systems.

The methodology used in the IIASA study is based on the work of H.J. Otway and M. Fishbein (1976): "The Determinants of Attitude Formation: An Application to Nuclear Power," (RM-76-80, International Institute for Applied Systems Analysis; Laxenburg, Austria). The authors of the present study are K. Thomas, D. Maurer, M. Fishbein, H.J. Otway, R. Hinkle, D. Simpson. ("A Comparative Study of Public Beliefs About Five Energy Systems"; RR-80-15, April 1980. International Institute for Applied Systems Analysis; Laxenburg, Austria.) It was brought to my attention by Miss Elizabeth Swaton of the Radiological Safety Section in the IAEA. She was kind enough to discuss the report and its implications with me, especially in the context of risk assessment studies.

The stratified sample group chosen for study was entirely from Austria controlling for geographical location (Vienna, provincial capital, and rural), and for sex, age, and education. The total of usable interviews was 224.

One of the measures chosen was the overall attitude toward each energy system. The rating of each attitude was on a series of 7-point scales (+3 to -3), with endpoints labeled with adjective pairs such as harmful/beneficial. A previous study had identified and validated 5 applicable adjective pairs for each of the energy types: good/bad, harmful/beneficial, harmonious/controversial, acceptable/unacceptable, moral/immoral. Thus with 5 pairs and a scale of +3 to -3 it was possible to compute an "overall attitude" with a range of values from +15 to -15. The frequency distributions of scores obtained in this way are shown in Figure 1.



after IIASA RR-80-15, 1980

Figure 1

Three distinct distributions were obtained. Hydro and solar are virtually the same as were the fossil fuels, coal, and oil. The distribution for nuclear energy is quite different. There are virtually no negative attitudes for solar and hydro. For the fossil fuels most of the attitudes are rather positive, with relatively few negative. Nuclear has a strong negative component as well as a positive one. In fact nuclear power is the only energy system that contains the element of " "polarization."

A second kind of measure was a more detailed examination of public beliefs. This study considered the public's response to a group of 5 so-called belief dimensions. These were defined and described in the following way:

(1) Economic benefit: Good economic value, increased standard of living, increased employment, increasing Austrian economic development.

(2) Environmental risk: Air pollution, water pollution, production of noxious waste, exhausting natural resources.

(3) Indirect risk: Changes in man's genetic make-up, increasing rate of mortality, formation of extremist groups, a police state.

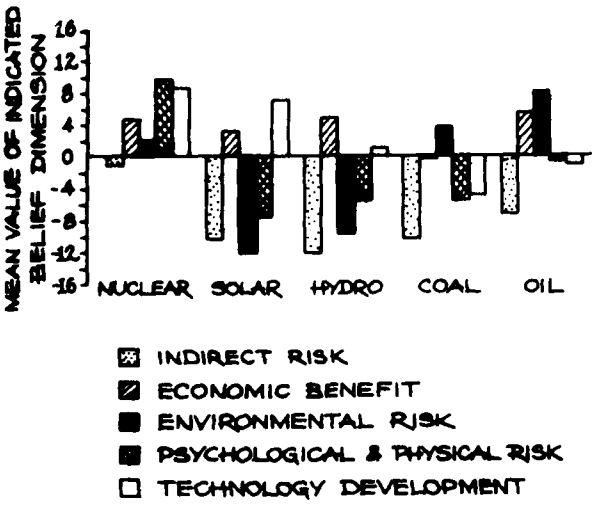
(4) Technological development: New forms of industrial development, new methods of medical treatment, technical spin-offs.

(5) Psychological and physical risk: Accidents which affect large numbers of people, exposure to risks one cannot control, rigorous physical security measures, hazards caused by human and material failures.

These belief dimensions were measured by asking the subject to indicate his (her) judgment of the truth of the statement on a 7-point scale (+3 to -3), with end points labeled likely/unlikely. For example, the use of coal leads to air pollution.

LIKELY +3 +2 +1 0 -1 -2 -3 UNLIKELY
(one of these is chosen)

The results of this measure are summarized in Figure 2.



after IIASA RR-80-15, 1980

Figure 2.

The ordinates are mean values for each of the 5 belief dimensions, obtained for each of the 5 different energy types. The ordinate values have no absolute significance, and only ratios have meaning; e.g., the value of "Environmental Risk" for Nuclear compared to that for Solar.

Summary of Results. All the energy types except coal were believed to lead to economic benefits. The public believed that fossil fuels and nuclear would lead to environmental risks but solar and hydro would not. On average it was not believed that any of the 5 energy types would lead to indirect risks (police state, etc.), but were less certain of this for nuclear power. It was believed that nuclear and solar, but not coal, would lead to technological improvements. Only nuclear was perceived to have psychological and physical risks, whereas solar was perceived as the least risky.

One or two comparisons of these findings may be made with Table 3 of *ESN* 34-11:521 (1980) Whereas the public belief about fossil fuels is that there would be little physical risk, the assessment report shows these energy types to have the highest risk factors for the public in terms of accidental death and fatal disease. Further, while the public belief is that solar is the least risky energy type, the risk assessment study shows this to be the highest risk form for the occupational group in the categories of accidental injury and accidental death.

While these studies are preliminary in nature with relatively small numbers of persons involved, they underline the need for similar studies to be made in various countries. At the very least policy makers and decision makers will gain some insights into the concerns of the public and the perceptions and beliefs that are held. It also suggests that educational programs for the public would be helpful. (Moses A. Greenfield)

OCEANOGRAPHY

THE MARINE STATION AT VILLEFRANCHE-sur-MER

Prof. C. Vogt, an associate of Louis Agassiz and later professor of zoology and geology at the University of Geneva, is credited with making the first systematic study of pelagic fauna in the sea. This study took place during the winter of 1846-47 off the town of Villefranche-sur-Mer (5km east of Nice, France). Sometime later, in 1884, A. Korotneff, a Russian biologist from Kiev, established a small marine biological station at Villefranche for the use of Russian marine biologists. The laboratory is now called the Station Zoologique (Zoological Station) and since 1932 it has been under the jurisdiction of the University of Paris.

In 1957, the University of Paris established a second laboratory, the Station de Geodynamics Sous Marine (Marine Geophysics Station) at Villefranche. This was followed in 1963 by the establishment of the Laboratoire de Physique et Chemie Marines (Laboratory of Physical and Chemical Oceanography). The last-named laboratory is an integral part of the Laboratory of Physical and Chemical Oceanography at the Pierre and Marie Curie campus of the University of Paris (*ESN* 33-8:333 [1979]).

A total of 150 individuals are in residence at the three laboratories in Villefranche. Fifteen others, who are employed by the French Atomic Energy Commission, do research on the physiology of marine organisms. Thus Villefranche has one of the larger marine science complexes in Europe. Prof. Paul Gougis is director of the Zoological Station and is also nominal director for housekeeping and facilities for the whole Marine Science Station.

All four laboratories are located in an old military establishment on the waterfront. The Zoological Station is housed in an interesting, picturesque edifice, formerly a military jail, that was built in 1769. Its main room, which is windowless, is two stories tall, and has dimensions of about 10 m by 30 m. Here galley slaves were quartered, chained to individual iron rings fastened to the stone floor. One can still see the orderly rows of plugged holes in which the rings were secured and can easily imagine what a hellhole the place must have been. Now the big room is used as a storeroom and is especially good for drying and storing large nets. Below is a vast, cavernous, vaulted cellar that is used for saltwater experimental tanks. Nearby is a long, narrow, two-storied building, originally a barracks, that contains the other three laboratories. It has been beautifully renovated on the inside. Its solid stone walls more than a meter thick, kept the interior nice and cool on the sweltering hot day of my visit in July.

The Atomic Energy Commission laboratory was completely closed for vacation when I was there, so I did not have the opportunity to visit it. A brief listing will be given of marine biology and geophysics studies at the station. The remainder of the article is devoted to activities in the Laboratory of Physical and Chemical Oceanography.

The following research programs are among those being carried out by the Zoological Station: (1) The biology and physiology of planktonic organisms that are reared in the laboratory, (2) Experimental studies of primary productivity, (3) Biochemistry of plankton, (4) The biology and reproduction of echinoderms and siphonophores, (5) The physiology of osmoregulation in marine organisms, (6) The cytology of microtubes, microfilaments and motile cells, and (7) Mathematical models of primary production and plankton ecology.

Programs in the Marine Geophysics Station include: (1) The study of stable continental margins along the Spanish Coast and in the Gulf of Guinea, (2) The study of active continental margins of the Agean Arc along the Tyrrhenian Sea and bordering the Ligurian Sea, (3) The study of deep sea sedimentation on the Mediterranean coast of France with emphasis on the deep sea fan of sediments off the mouth of the Rhone River and in deep sea trenches. Prof. G. Boillet is the scientific director of this station; J. Mascale is the administrative director.

The host for my visit to the Marine Station was Prof. A. Morel, director of the Laboratory of Physical and Chemical Oceanography, whom I have known for many years because of my early interest in his speciality, optical oceanography. The laboratory has grown recently under his capable direction and in contrast to many laboratory directors whom I have interviewed in Europe, he is optimistic about continued growth.

Morel was well prepared for the interview and gave a lucid presentation in perfect English.

The laboratory has 18 scientists, including 3 who are working on their doctoral theses, plus 3 engineers. I noted with interest that aside from the engineers there were no other support personnel such as secretaries and bookkeepers. Morel informed me that most marine scientists in France worked in one way or another for the French Government and that there was currently a virtual freeze on establishing new governmental

positions. For this reason most of the graduate students at the laboratory are foreign students, usually from developing countries.

In the past the laboratory's primary interest was in a worldwide inventory of the optical properties of seawater and the penetration of solar energy into the sea. This research was discussed in a previous article on the parent laboratory in Paris (*ESN* 33-8:333 [1979]). More recently the laboratory has branched off into other areas of research. This included a conventional hydrographic survey of the nearby Ligurian Sea. At present, the laboratory is studying the heat, salt, and kinetic and potential energy budgets of the waters of the Ligurian Sea and other areas in the Mediterranean Sea. These budgets are dependent upon local climate and weather and on the characteristics of Atlantic water. Mean water fluxes for cross-sections are being calculated. Eventually they hope to study the budgets of the whole area. Surveys are made with systems of towed instruments that are monitored aboard ship by a computer. The parameters that are monitored and recorded are temperature, salinity, oxygen content, nutrient materials, pigments such as chlorophyl, turbidity and sometimes plankton. Most of the instruments used were designed and built at the laboratory. The laboratory is particularly interested in the Ligurian Sea because of a nearly permanent gyre that is located there. Biologically rich frontal zones are associated with the gyre where very high concentrations of chlorophyll (4-5 mg/m^3) are found in the springtime . The driving forces causing the gyre are not well understood but are probably related to local meteorological conditions. This research on the gyre is part of a subprogram of GARP (Global Atmospheric Research Program) called ALPEX (Alps Experiment). Local weather to the south and southeast of the Alps is strongly influenced by those mountains. A number of Mediterranean nations have scientists working in ALPEX with the hope of determining the effects of the Alps on local weather.

Since 1970 the laboratory has devoted a great deal of time and effort to all aspects of the light budget in the surface layers of the sea. These data are used to help calibrate data obtained from teledetection by satellites and aircraft. The end result is to be able to teledetect the pigment content and suspended material content of near-surface waters. Morel stated that this could now be done in mid-ocean in the absence of turbid suspended materials derived from the land. The precision is not great, but it is improving.

The laboratory is purchasing a large Hewlet-Packard computer system to be used for processing satellite data from the French Space Meteorology Center in Lanion (*ESN* 34-10:481 [1980]) in order to obtain data on infrared and visible radiation that is emitted from the sea surface.

To date the laboratory has measured the spectral distribution of sunlight at various locations in the world oceans. Their specially designed instrument uses a rotating grating, analogous to a prism, that can accurately measure the whole spectrum *in situ* in a very short time.

The laboratory is also measuring the scattering properties of all kinds of suspended particulate matter in the sea including phytoplankton. They have developed a theoretical scattering model for phytoplanton. The laboratory has a phytoplankton culture room where, at the time my visit, they were growing 52 different species of phytoplankton and measuring their optical properties. It is fundamental in their study of remote sensing to know both the backscattering and the absorption of light by phyoplankton. Selective absorption can change the apparent color of the water.

As an offshoot of the phytonplankton studies, they have a very active program in studying the therapeutic properties of phytoplankton extracts. Extracts of about 50 marine planktonic algae strains in culture have been tested for antifungal activity and five were found to inhibit the growth of pathogenic fungi. One had antibiotic properties and some were antimitotic (stopped cell development). This research is partially supported by the French Naticnal Institute for Medical Research. Organic compounds in phytoplankton excretions have also been identified.

Other chemical studies underway include the carbonate cycle and exchange between the ocean and the atmosphere. Experimental studies have been carried out to determine the relationships be between natural copper complexes and their toxicity to phytoplankton. The toxicity depends on the physiochemical form of the metal. One species of phytoplankton was found to liberate substances into its culture medium that detoxify and complex the copper. Seasonal variations of heavy metals in plankton in the Mediterranean are underway with emphasis on zinc, copper, and cadmium in zooplankton.

I was very much impressed by everything I saw in Morel's laboratory. The relatively small staff is carrying out a prodigious amount of research. I would encourage oceanographers to visit this up-and-coming small laboratory. (Wayne V. Burt)

PHYSICAL OCEANOGRAPHY IN TRIESTE

Some years ago I visited most of the oceanographic laboratories in Italy and found them housed in old and inadequate buildings, some dating from the Renaissance. During my visit to the Observatory for Experimental Geophysics (Osservatorio Geofisico Sperimentale) in Trieste on 19 August 1980, I was agreeably surprised to find that the laboratory that conducts physical oceanography research was housed in a modern building on the waterfront beside a small boat-and-yacht harbor with several large swimming pools and recreation areas nearby. At present the laboratory has no ships of its own, but uses charters or government-owned vessels. Twenty people, half of whom are senior research workers, work in this laboratory, which is called the Marine Laboratory. My host, Dr. Ezio Accerboni, is the director. He informed me that 95 percent of the laboratory's research is concerned with physical oceanography and the remainder with the study of concentrations of heavy metals in the marine environment.

A second institute in Trieste, Instituto Sperimentale Talassografico, which I did not visit, devotes most of its efforts to chemical oceanography.

Accerboni is a successful entrepreneur who has been able to obtain from 80 to 90 percent of the funding for research at the Marine Laboratory from industry while only 10 to 20 percent has come directly from the Italian government. This situation is unusual among European marine science laboratories, most of which depend on direct governmental support for the bulk of their funding. The work for industry consists of obtaining environmental data for ocean engineering studies similar to the studies done by Heriot-Watt University in Edinburgh (*ESN* 34-1:38 and 34-9:458 [1980]).

The largest ocean engineering study which the laboratory has completed was performed for the joint Algerian-Italian project to construct a seafloor natural-gas pipeline from Tunisia to Italy (*ESN* 34-6:297 [1980]). The companies involved wanted to know the extreme surface-wave conditions that could occur during the time the pipeline was being placed on the seafloor as well as the extreme currents that could be expected to impinge on the pipeline during the laying operation. Eleven current-meter moorings and three surface-wave spectra recorders were anchored in the area where the pipeline was to be laid.

A second major study was concerned with the oceanographic and meteorological environmental factors that would influence the design, construction, and maintenance of a proposed bridge across the Straits of Messina between Sicily and the toe of Italy. The field work has been completed and the data is being analyzed.

An interesting study is underway to determine the stresses on and the vibration characteristics of a seafloor pipeline across the Straits of Messina.

Another ongoing project is designed to define the hydrodynamics and characteristics related to the biologically rich northern part of the shallow Adriatic Sea. The Po River, with its tremendous load of pollutants from industries in northern Italy and nutrients that are derived from fertilizers applied to the rich agricultural areas drained by the Po, enters the Adriatic south of Venice. Normally a counterclockwise gyre in the northern Adriatic carries the Po effluent southwest along the eastern Italian coast. However, abnormal sustained winds occasionally move water uncharacteristically from the mouth of the Po across the Adriatic Sea to Yugoslavia, upsetting the biological balance of the Istrian waters by bringing about dense phytoplankton blooms. Seechi disc readings (the depth to which one can just see a white dinner plate) change from a normal 10 m to less than 1 m inhibiting normal primary productivity to the very surface of the sea. At the present time the study is a cooperative one between the Trieste laboratory and several Yugoslavian coastal marine laboratories.

For a number of years the laboratory has been studying astronomic tides and wind tides and surges in the northern Adriatic Sea with particular emphasis on flooding in the city of Venice. The wind tides tend to have the greatest magnitude at the head of the sea where Venice is located. Wind tides 126 cm in height have been recorded in Venice after a period of sustained high winds from the south while the rise in the water level at the southern end of the sea was only 10 cm. These wind tides may be several times the height of the astronomic tides in Venice. Forecasts must be made so that necessary precautions against flooding can be taken in advance. The laboratory has been developing and improving mathematical models of wind-induced increases in sea level since 1971 and they believe that they now have a very accurate working model. Improvements in the model were made by hindcasting for wind tide situations in the past. The goal is to forecast for 9 to 12 hours in advance. The present limiting factor in forecasting wind tides for Venice involves the meteorological forecasts that are made of winds over the area. These forecasts are not as accurate as the scientists at the Marine Laboratory would like them to be. Interestingly, the forecasts come from England.

In addition to forecasting, the laboratory monitors wind tides in the northern Adriatic by shore-based tide gauges. The tide gauges are connected by telephone lines that feed their data directly into the master computer in Trieste in real time. Also, two large buoys are anchored in the middle of the Adriatic Sea, one due east of the mouth of the Po River and the other farther north. The buoys which are 6 m in diameter, were built and equipped with electronics by General Dynamics. They have been in use since August 1968 and are replaced by spares when they are brought into Trieste for maintenance. Air and sea surface temperature, air pressure, wave height, and wind velocity are recorded, and data are sent by radio each hour to the Trieste computer. Humidity, sea levels, and current flow have been recorded in the past. New Neil Brown acoustic current meters are ready for installation in the near future. Buoy data are used in forecasting weather and wind tides and as part of the study of the dynamics of the Adriatic. The minicomputers on the buoys can be programmed to transmit data at any specified time intervals and can integrate data from the sensors over arbitrary periods of time.

All in all, 16 projects are underway. The director would not allow me to have a list of those projects, explaining that a number of them are "company classified". This is a problem that I had not experienced in any US university, but frequently have had to tussle with in Europe.

The laboratory puts a great deal of effort into the calibration of instruments, and it has the most up-to-date and complete calibration laboratory I have ever visited. Many systems are in duplicate for cross checking. The calibration laboratory is as clean and neat as a hospital operating room, with air conditioning, cork-insulated tiled floors, and glistening white walls. The equipment includes a Canadian AUTOSAL for calibrating their system for obtaining salinity, and a very accurate absolute pressure device made by Desgranees et Huot in France. It is accurate to one part in 10,000 at pressures up to 800 bars.

The latest piece of equipment is one for calibrating air pressure sensors to an accuracy of 1/10 mb. Accerboni has found that air pressure data from the standard meteorological data network has an accuracy of ±0.5 mb, and he wants to improve this accuracy to ±0.1 mb in order to improve wind forecasts.

A 6,000-liter tank with a variable salinity and temperature system is used for calibrating their Neil Brown CTDs (conductivity-temperature-depth sensors). Both temperature and salinity can be varied slowly. Polarographic sensors to measure dissolved oxygen have been fitted to the CTDs. A preprint, No. 1-1979, describes the oxygen sensor system and its calibration.

The laboratory now uses a new state-of-the-art solid-state current meter made by NBA Controls Ltd. in Farnborough, England. Accerboni stated that they now regularly obtain over a 90 percent data recovery rate with the NBA instruments, which also record temperature and conductivity. The key to the NBA instruments' high yield of data is a second tape head between the head that records the data on the tape and the uptake tape reel. When acoustically interrogated, the second head sends an acoustic signal which indicates whether the first head is recording data properly. With this system, each current meter can be checked periodically *in situ* and can be recovered if it is malfunctioning.

It was apparent that the Marine Laboratory is not hurting for funds for equipment. I was shown the latest group of NBA current meters, costing in all about $80,000. They have almost a half million dollars invested in 60 NBA current meters.

The Marine Laboratory's parent organization, the Observatory for Experimental Geophysics, is a government laboratory under the direction of the Ministry of Public Education. It is independent of the University of Trieste although some staff members have professorships from that university. The university does not offer a PhD in oceanography so the marine laboratory does not have the benefits of PhD candidates doing their research. The only educational courses given at the laboratory are occasional month-long courses in obtaining and processing current meter data.

The laboratory has grown rapidly in the past five years and Accerboni is optimistic about further growth in the future. It is a gung-ho outfit doing really good research and has an able, energetic director. (Wayne V. Burt)

OPERATIONS RESEARCH

OPERATIONS RESEARCH AT CHARLES UNIVERSITY

Charles University in Prague may or may not be the oldest continuously operating university in Europe, but having been founded in 1348 by the Germanic peoples who ruled Mittel-europa from Prague, it has a long and honorable history. At the present time its facilities are scattered all over Prague. I visited the Department of Cybernetics and Operations Research in the Faculty of Mathematics and Physics, located in a stately old building directly across the Malostranské Square from the magnificent St. Nicholas Cathedral, and in the shadow of the Hradčany Castle which is the dominant feature of the city.

The head of the department is Milan Vlach, who took his undergraduate degree at Moscow University, and his doctorate ("Candidate") at Charles University in 1968. He spent the next two years teaching in Utrecht and Delft (he speaks, of course, the usual languages, but even for a Czech a mastery of Dutch is unusual). His degrees are all in mathematics.

One of Vlach's research interests is in what he calls a unified theory for optimal control and mathematical programming. This is arcane stuff, involving conical approximations to sets in linear space, the proof that certain families of sets have empty intersections, and finding functions which separate these families. Vlach's other research interests are in combinatorial scheduling problems, and in the theory of complexity of problems and algorithms, as described in *ESN* 34-11:532 (1980). He assured me that he has practical interests; that he is in contact with factories in Prague, and has been solving realistic scheduling problems for them. Vlach is one of the few Czechs who publish extensively in the English language, although most of his writings appear in non-refereed publications such as conference proceedings.

As indicated, Vlach's interests are highly theoretical and this flavors the entire department. There are about 50 students per year graduating from the undergraduate program and another five at the doctoral level (at the moment, Vlach has three doctoral students working for him personally), and most of the instruction at both undergraduate and graduate levels is well-nigh indistinguishable from pure mathematics. It should be noted that this department is not in the Engineering Faculty, but in the Mathematics and Physics Faculty. Such textbooks as Wagner or Hillier & Lieberman, from which operations research is often taught in the US, would not be considered sophisticated enough for use here.

The department is divided into two groups: one on computer science (without a computer!), the other on optimization, with six or seven people in each group. A third group, on computer programming, is to be added next year; but again, it is intended that these people will study the theory of programming rather than actually programming any real computers.

Among the people doing interesting research in this department are P. Štěpánek, Renc Zdeněk, and Michal Chytil. Each has the doctorate ("Candidate of Science") from Charles University.

Štěpánek was originally a logician who became interested in the applications of formal logic, especially Boolean models, to computer science. He now works in logic programming, using a language called PROLOG which was designed in France some 8 years ago from English ideas for non-numerical computations such as syntactic programs. He has recently proved a theorem to the effect that every computable function can be computed by binary "horn clause" programs. I gather that this is analogous to the famous theorem that every computable function can be computed by a Turing machine.

Zdeněk is interested in logic and set theory, and his research is on the applications of logic and artificial intelligence to the formation of hypotheses. He told me of one example of a reputed application of this theory to medicine: there exists a great deal of data on the symptoms of illness, and he is interested in forming rational hypotheses concerning the connection between different symptoms.

Chytil is interested in automata theory and formal languages, and specifically the application of the results of complexity theory to formal languages. For example, he has been interested in the measurement of the degree to which languages are dependent upon context. Natural languages are highly context dependent while programming languages tend to be context free. Several approaches taken by different people to the measurement of context dependency turn out to be equivalent. Chytil is trying to find out why, and to apply this theory to compiler design, as well as to the theory of Turing machines.

I was suprised at the gulf between theoretical and applied operations research in Czech universities, especially at the most prestigious of these, the

Charles University. The situation is exacerbated by the natural difficulties in East-West dialog (through the Iron Curtain), and by the lack of publication in other than Slavic languages. While the personnel of this group appear to be extremely bright and although their research may well have theoretical significance, it seems unlikely that there will be much fruitful interaction between groups such as this one and American operations researchers in the near future. (Robert E. Machol).

THE SIXTH INTERNATIONAL SEMINAR ON ALGORITHMS FOR PRODUCTION CONTROL AND SCHEDULING

These conferences have been held in 1966, 1968, 1970, 1973, 1976 and 1980, the first two in Ostrava, in north-central Czechoslovakia, and the last four, all of which I have attended, in Karlovy Vary, in northwestern Czechoslovakia. (Karlovy Vary is also known as Carlsbad; the former name is Czech, the latter is German, and both translate into "Charles' Bath." The name arises from the famous spa located there.) The conferences are nominally run by the House of Technology in Prague, but this organization primarily handles the clerical functions. The technical sponsorship of the conference is with INORGA, an organization which will be the subject of a separate article in ESN next month.

The Sixth Conference was held Sept. 16-18 in what was formerly the Grand Hotel Pupp, subsequently the Grand Hotel Moskva-Pupp, and now the Grand Hotel Moskva (Moskva is the Czech and Russian word for Moscow). The accommodations were elegant if expensive, and the meeting rooms were comfortable and acoustically and visually admirable. Each attendee had a fine little portable radio with channels on which he could receive the English, Czech, or Russian translations simultaneously with good fidelity. Unfortunately, most of the translators from Czech into English were not technically qualified and did not understand what they were translating, and there were no translations from Russian directly into English. The Russian papers were translated into Czech, with Czech-English translators listening to this simultaneous translation and then simultaneously translating into English. The result was moderately incomprehensible.

Those papers which had been received on time (seven months before the seminar) were published, each in its original language (English, Czech, or Russian). English-language summaries were provided for the Russian papers, but in most cases these summaries were not easy to understand. Through some oversight there were no English abstracts of the Czech papers. So, with some exceptions the technical benefit of the conference was reduced to those papers presented in English. These included the papers given by Swedes, Germans, Britons, an American, a Rumanian, and some others.

In the opening plenary session of the conference, Miroslav Knotek of INORGA welcomed the guests and pointed out that there were more than 60 foreign participants (in addition to a large number of Czechs) from 14 countries, including for the first time two representatives of developing countries, namely Algeria and Cuba.

The next speaker was Josef Kriz, Minister of Metallurgy and Heavy Engineering, who talked about important tasks for the future, the necessity for control systems to include all processes of production and management, the necessity for systems to be interactive, and the necessity for systems to be modular. Kriz expressed the hope that this conference would aid in these tasks.

Peter Čáslavaký, Director of INORGA, talked about eliminating the psychological barriers to computers and automation. He gave a number of fascinating statistics, such as the fact that 80% of the factories in Czechoslovakia now are automated in some sense, and that 38% of the implementation tasks in these factories have been computerized. He further asserted that by the year 2030, 80%-90% of the population of Czechoslovakia will be in direct touch with automation and with computers.

One Czech paper which I was able to understand (partly because there was a technically trained translator at this session and partly because I talked to the author afterwards) was that given by Milan Vlach of Charles University (see separate article in this issue) on the complexity of problems. He first defined information complexity, which is quite different from the more familiar computational complexity. Given, for example, the problem of maximization or minimization of a function subject to constraints, he talked about a "black box" which answers questions of the form: "given a vector, what is the value of the objective function for this vector?" or "is this vector within the feasible region?" His measure of informational complexity is the number of such questions which must be asked, and the size of the error. Specifically, he takes the worst case of number of questions and size of error for a given method or algorithm, then takes the best of these methods, and finally defines complexity to be the number of questions required to achieve a given accuracy.

Vlach has been trying to obtain upper and lower bounds for this measure of complexity. As an example, for continuously differentiable functions to be optimized, with compact sets for feasibility regions, the lower bound grows as $k(s)(1/r)^n$ where s is the feasible set, k depends only on s (not on the accuracy), r is the relative error, and n is the number of variables (that is, the dimensionality of the problem). Similarly an upper bound on complexity is available for convex programming. These and other results are given in a book which Vlach highly recommended, entitled "Complexity and Effectiveness of Optimization Methods," by Nemirovskii and Yudin, published by Nauka in Moscow in 1979. Vlach praised the book highly and stated that it was loaded with important results. Unfortunately it is in Russian, and he is unaware of any translation of the book into English. He asserts that the whole point of view is not only very useful but also quite different from the concepts of Cook and Karp regarding NP Complete problems.

In his talk, Vlach outlined these concepts of computational complexity, and classified scheduling problems as to those which were P, those which were NP Complete, and those whose classification was not known. Here P stands for polynomial and implies that the computational complexity does not grow exponentially with the dimensionality of the problem. NP Complete is a class of problems all of which are more or less equally difficult, and for which the computational difficulty may grow exponentially.

In the question period Vlach was asked to comment on the theoretical (as distinguished from the applied) complexity of particular algorithms, in light of the fact that the Khachiyan algorithm, which is known to be P, is in practice nowhere near as useful as the simplex algorithm for the same problem which is known not to be P. Vlach responded that for any given problem for which there were two algorithms, one P and one NP Complete, even if the former seemed comparatively inefficient (as in the case of the two cited algorithms for the linear programming problem), there exists a size of problem such that above that size the P algorithm is better. Admittedly, in the case of linear programming that size is larger than any practical problem at the present time. The important thing about Khachiyan's work is that he has proved that there exists at least one P algorithm for this problem. There is therefore hope that other P algorithms will be found which are more efficient than Khachiyan's, in which case the crossover size may become much smaller.

A paper which I found particularly interesting because it had a nonintuitive conclusion was "Evaluation of Payment Consequences from the Control and Design of Production Systems," by Robert W. Grubbström and Anders Thorstenson of the Department of Production Economics at Linkoping Institute of Technology. They were specifically interested in the evaluation of capital costs for inventories and for work in progress. The basic idea is that the ultimate economic consequences must be evaluated by considering external payment streams or cash flows, and they concluded that conventional costing methods underestimate such costs by hundreds of percent, especially when the profit margins are high. Specifically, for a profit margin of 20% the standard costs should be increased by factors of about 2, while for a profit margin of 73% the factors should be in the neighborhood of 10. These conclusions were confirmed not only by theoretical analysis but also by extensive simulation study.

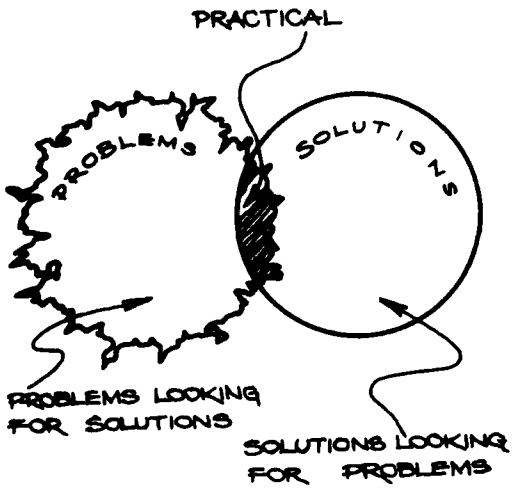
On mature consideration, these conclusions are not as non-intuitive as they seem at first sight. If one is trying to determine the proper amount of inventory to maintain in order to maximize profits, and if in fact the profit rate is high so that the value of the goods in terms of price is much higher than the value of the goods in terms of cost, then it is the price figures that should be used to evaluate the true worth of the goods (especially finished goods) rather than the cost figures which are used in the classical methods.

The paper which excited the most interest and the most discussion was given by an American, Stephan Sunderland of Control Data Corporation, entitled "The Automated Factory--A Reality." The factory in question was for the investment casting of turbine blades for a jet engine to be used in a military aircraft. The design of the factory began in 1972, and the foundry went on line in late 1977. The final facility contained over 100 integrated machines costing in excess of 10 million dollars. The definition, design, and implementation of the control and automation systems required an effort in excess of 70 man-years.

In the question period, Sunderland was asked exactly how many people were required to operate this "automated factory." While no precise number was ever stated, apparently there are a number of functions, such as the furnace, which could not be automated; and there are a number of tasks, from materials handling to sweeping floors, which still

had to be done by hand. It thus appears that the concept of an automatic factory, without any human beings in control, has not yet been realized. Sunderland also declined to answer some other questions about the constraints under which optimization had taken place, presumably because of the sensitive nature of the product being manufactured in the factory. Finally he was asked whether it would take less than 70 man-years if he had it to do over again with all the lessons that had been learned; his response was that he probably would not anticipate saving much engineering time in the design of the system, although he would anticipate saving on some of the software. He did say that the system was very "stiff," and gave as an example the fact that a 2-ton 3-axis manipulator, which must move at several feet per second, must be able to position accurately to within 0.040 inches.

Martin Walbank of the Institute of Science and Technology of the University of Manchester presented a paper on what we should be doing as scientists about planning and controlling production, and particularly lot-size control. He started by drawing the attached Venn diagram, showing the area of problems, which has very fuzzy boundaries, and the area of solutions, which is clearly defined, but which unfortunately does not largely overlap the area of problems. The area in which practical results can be obtained is the shaded area on the diagram, namely the small portion in which they intersect.



Computerized systems frequently increase productivity while reducing the work in progress by 20% to 30% but Walbank asserted that this could have been achieved without the computer. The improvements were due largely to better data, which was incidental to the computerization. "After all," said Walbank, "we have run factories in the past without computers, and so we should now use the computer as an aid and not look for an optimal computer solution to problems such as scheduling problems." As a specific example, he talked about the Wagner-Whitin algorithm for lot sizing, and showed quantitatively how the "optimal" solution obtained from this algorithm could be greatly improved if backlogging were allowed. This, he asserted, was an example of how better decisions could be made if more options were made available or more information could be obtained.

The final plenary session included a paper on UNIDO, the United Nations Industrial Development Organization, which has the responsibility to promote and accelerate the industrial development of developing countries and which is very interested in the kinds of techniques discussed in this seminar. There was also a long address by Dr. Khinov, Vice Director of the International Institute of Control problems in Moscow, an institute which is "international" in the sense of being a cooperative effort among all of the COMECON countries and some additional socialist countries such as Mongolia.

After the conference was over, I noticed that the official Russian name for the conference was quite different from the English name, namely "Algorithms for control of metallurgical and machine-construction production." It never really was clear what the unifying concept of the conference was supposed to be. Because it was financed and controlled by the Ministry for Metallurgy and Heavy Engineering, there were a great many papers on metallurgical factories. Except for plenary sessions Tuesday morning and Thursday afternoon, the conference was divided into two simultaneous streams of papers, one of which was devoted almost exclusively to iron and steel, and problems involved in the production of these materials. A few papers, like that of Vlach, mentioned above, were specifically on the subject of algorithms; others, such as that of Sunderland, were simply on the subject of automation in general.

On the whole, because of this lack of coherence, and because of the poor translation facilities and the poor organization of the conference, I found it much less rewarding than the previous conferences on the same nominal topic. At this point it does not seem clear whether or not there will be in the future a 7th conference with the same title. (Robert E. Machol)

PHYSICS

ATOMIC HYDROGEN IN AMSTERDAM

Like many other large universities, the University of Amsterdam is not monolithic, but is located in many buildings distributed throughout the city. The Natuurkundig Laboratorium is in the southeast portion of the old city in a building shared with the Van der Waals Laboratory. There I visited Prof. Isaac Silvera, an expatriate American from San Diego, in his cryogenics laboratory where he has been studying atomic hydrogen since 1972.

Silvera and his coworker, Dr. Jook Walraven, reported earlier this year on the stabilization and physical properties of low-temperature atomic hydrogen. (*Phys Rev Lett* 44 164 [1980]). In April, Silvera presented an invited paper on this subject at the 1980 Annual Conf rence of the Condensed Matter Division of the European Physical Society.

Silvera and Walraven have succeeded in creating atomic hydrogen in a state called spin-polarized hydrogen (denoted $H\downarrow$). This is a substance of great interest because it is predicted to be gaseous at absolute zero temperature as a result of weak interatomic interactions and large zero-point motion. The hydrogen atom has a nuclear spin of $I = \frac{1}{2}$ and an electron spin of $S = \frac{1}{2}$ so that it is a composite Boson with a total spin of 1 or 0. Such a gas is expected to show both Bose-Einstein condensation and superfluidity as a gas. In the case of small interactions between particles, the critical condensation temperature is $T_c = 0.0839\ h^2\ n^{2/3}/mk_B$, where n is the concentration, m is the atomic mass, and h and K_B are Planck's and Boltzmann's constants. At a concentration of 10^{24} atoms/m^3 this relation gives a critical temperature of approximately 16 mK which is within the range of current cryogenic techniques. To date, concentrations of approximately 5×10^{22} atoms/m^3 have been achieved for which the predicted condensation temperature is somewhat lower at approximately 2 mK.

Most atomic physics texts discuss the hydrogen molecule in zero magnetic field. They show that as a result of the exchange energy between the two electrons the potential energy has a minimum of -4.48 eV when the electron spins are antiparallel. Zero-point energy is not large enough to thoroughly overcome this relatively deep potential and consequently this singlet state is a bound one.

Silvera and Walraven point out that if the electron spins are coupled in a parallel fashion the resultant state is a triplet with, of course, no binding in zero magnetic field. When a magnetic field is applied, the triplet state splits into three, one of which is actually lower at large distances than the antiparallel state. However, as a result of the small mass of the hydrogen atom, with its consequent large zero-point energy, triplet hydrogen has no bound state. This gas of hydrogen atoms in which all pairs interact through the triplet potential, and only the lowest electronic state is occupied, is what Silvera and Walraven call "spin-polarized hydrogen." They have stabilized the gas by suppressing surface and volume recombination into the antiparallel (molecular) state sufficiently to increase the lifetime of $H\downarrow$ by many orders of magnitude (10^6) over that expected without spin stabilization.

The stabilization of atomic hydrogen was carried out through six important steps: (1) development of a source of cold hydrogen atoms, (2) polarization of the electron spins, (3) suppression of wall recombination, (4) confinement of the $H\downarrow$ gas in space, (5) achievement of low temperatures, and (6) the detection of the gas of $H\downarrow$. Some details of the experimental apparatus have been described in their recent publication noted above.

The primary source of hydrogen atoms is a room-temperature microwave discharge in molecular hydrogen gas. Dissociated atoms are guided away from the discharge through Teflon tubing into a cryogenic chamber, maintained at 4.2K, where the atoms are thermalized. A coating of H_2 on the walls of this chamber inhibits surface recombination so that the emergent atoms are cold and relatively plentiful. Cold hydrogen atoms are necessary in order to provide a small heat load in the stabilization cell which operates below 1K, and to maintain the high density spin-polarized state.

After leaving the thermalizing chamber, the H atoms proceed toward the stabilization chamber which is maintained at a temperature of 0.3K by means of a pumped ^3He bath and is situated at the interior of a large superconducting solenoid (B~10T). The electron spins are polarized by a magnetic field gradient at the entrance to the solenoid, which is arranged so that the electron spindown states are drawn into the high field region and the spinup states are repelled. If these entering polarized atoms collide with the 0.3K wall, they will be thermalized and actually confined by the magnetic

field. However, at these temperatures, HO atoms will be adsorbed (and will thus be likely to recombine to H_2) on almost all surfaces. The exceptional surface, a crucial factor in the success of the experiment, is 4He which is superfluid at these low temperatures. As a result of the small interaction between H↓ and ^{4}He, coating the surfaces of the stabilization cell with ^{4}He results in a small adsorption, so that most of the H↓ atoms are thermalized and contained.

To prevent the ^{4}He film from creeping out of the cell and evaporating in the warmer regions, a second pumped ^{3}He bath is located so as to cool the intermediate region between the two chambers. Introduction of this second ^{3}He bath means that the ^{4}He will creep upstream beyond the bath to warmer regions before vaporizing and being driven back toward the stabilization cell by the pressure gradient. The second bath then serves to absorb most of the heat of condensation of the (now gas) ^{4}He, and also acts as a diffusion pump in that the more massive ^{4}He atoms collide with the H↓ atoms and compress them into the stabilization cell.

The presence of H in the stabilization cell is detected with a bolometer made from a Speer carbon resistor which has a large negative temperature coefficient of resistance. Ordinarily, the bolometer is covered by the ubiquitous ^{4}He film but it can be removed by passing enough current through the bolometer to evaporate the film faster than it can be replenished by creeping along the lead wires. In that case the H↓ atoms can condense and recombine on the uncoated bolometer with the recombination energy of 4.48 eV per pair producing an easily measurable temperature rise. The total number of recombining atoms can be experimentally determined by measuring the temperature rise of the cell with a second bolometer after recombination is initiated.

In the first experiments, H↓ at a density of 1.8×10^{20} atoms/m^3 was stabilized in a 7T field at a temperature of 0.270K. After a lapse of 532 seconds, this sample showed no measurable change in density. However, atoms do leak out through the open end of the stabilization cell by thermal diffusion, with a time constant of approximately one-half hour. The presence of H↓ atoms in the cell has been observed after 47 minutes, at which time the original concentration was reduced to between one-half and one-third of the initial concentration.

More recently, concentrations of 5×10^{22} atoms/m^3 have been achieved by Silvera and Walraven. As yet, they have found no fundamental limitation to increasing the density, although the lifetime of the denser samples is reduced, possibly as a result of 3-body recombination. They plan to continue refining the apparatus in an attempt to reach the higher densities which are predicted to be necessary for achieving Bose-Einstein condensation. Atomic deuterium is also of interest as a possibility for detailed studies of a Fermi system. However, preliminary experiments indicate that, for as yet unknown reasons, achieving high density samples is more difficult with this substance. (John R. Neighbors)

PRACTICAL PHYSICS IN HELSINKI

A handheld device for detecting detached retinas and tumors in the eye, a system for measuring paper tension in a paper-processing or printing machine, a noncontacting method for detecting surface cracks in metal, and a new type of infrared detector--these are just some of the devices and systems that have been developed or are under study by Prof. M. Luukkala and his group in Helsinki. Luukkala is professor of measurement methods and electronics in the Physics Department of the University of Helsinki, a chair that he has held since 1972. (The University of Helsinki is not to be confused with its sister institution, the Technical University of Helsinki, which is now located in Espoo, just outside Helsinki.)

Finland, a country of vast green forests, sparkling lakes, ultramodern buildings, and walled castles, has a population of 4.8 million. It is one of the younger countries on the political map, for it has only been independent since 1917. Prior to that, it had the status of a Grand Duchy of Russia for 108 years. For 700 years before 1809, Finland was dominated by Sweden.

Approximately 8% of the people living in Finland today speak Swedish. Out of consideration for this minority one finds not only street signs but also the names of banks and stores, and even the names on milk bottles in Swedish as well as in Finnish.

Helsinki, the capital, has a population of a little over ½ million; there are three other Finnish cities whose populations exceed 100,000. The institute now known as the University of Helsinki (in Finnish Helsingin Yliopisto) was actually founded by the then-Swedish government as an academy in Turku, 100 miles to the west of Helsinki, in 1640. It expanded over the years and during the Russian occupation became the Imperial Alexander University of Finland. In 1828,

after a fire in Turku, it was moved to Helsinki. Nearly 100 years later, in 1919, after Finnish independence had been achieved, its name was changed again, and it became the University of Helsinki. The university at present has about 25,000 students.

Physics study and research at the university is divided into the Department of Physics and the Department of Theoretical Physics. Luukkala is one of five professors in physics. He mentioned to me that his four colleagues are engaged in the usual studies carried out by physicists (crystal structures, structure and phase changes, x-ray diffraction, nuclear physics, etc.), as well as others of special interest to Finland, such as a study of friction between skis and snow. The department admits an average of th thirty students a year.

The time required for obtaining a degree (the Master of Philosophy) is a minimum of 5 to 6 years. The entire last year is gnerally spent on thesis research. A doctor's degree requires 2 to 3 additional years of work plus enrollment in two courses in theoretical physics.

Several of the projects of Luukkala's group are in the field of medical electronics and employ ultrasonic waves. One that has recently passed from the research to the commercial stage is an instrument, used for examing internal structure of the eye, which is now being manufactured at the Finnish company, Lasertek. In opera operation, a hand-held portion of the instrument contacts the outer surface of the patient's eyelid, while an intervening jelly layer provides the medium for tr transmitting ultrasonic pulses into the eye's interior. The 6-MHz transducer which transmits echo pulses into the eye and receives them back is moved at an angle over the eye. By combining ordinary A-scans (i.e., transducer voltage received vs. time) for different angular positions on a cathode-ray tube display, the system enables a physician to locate the source of an echo (such as a detached retina or a small tumor) to an accuracy of 0.3 mm in the three orthogonal directions. The transducer has 40% band width, so that it is able to receive pulse widths considerably shorter than one microsecond. Luukkala stated that this instrument sells for around fmk70,000 (approximately $20,000).

Closely related to this eye scanner, but considerably simpler and "just out of the laboratory" is an instrument that Luukkala called the Sinuscan. It is designed for detecting maxillary sinus disease. In the operation of the instrument, the face of the person being examined is contacted by a transducer which sends out and receives ultrasonic pulses. Electronic circuitry measures the time interval between the transmission of the ultrasonic input pulse and the reception of its echo from within the maxillary sinus and converts this into an easily interpreted display, on a series of light-emitting diodes, which tells the examining physician or nurse how much of the sinus is filled.

Again utilizing vibrational waves, this time of much lower frequency (500 Hz), is an apparatus that measures the tension of paper in a paper-processing or high-speed printing machine. The development of this instrument was financed by industry to prevent paper from tearing by being subjected to too great a tensile stress in such machines. (Papermaking and the manufacturing of papermaking machines are very important to the economy of Finland.) To determine the tension, the speed of membrane waves in the stretched paper is measured. As illustrated in Figure 1, a loudspeaker excit s bursts of 500 Hz waves in the center; microphones detect the time required to propagate the waves a given distance along the paper; and an electronic circuit then averages the propagation times up and downstream. Since the speed of membrane waves is directly relatable to the tension, this provides a simple method for measuring tension.

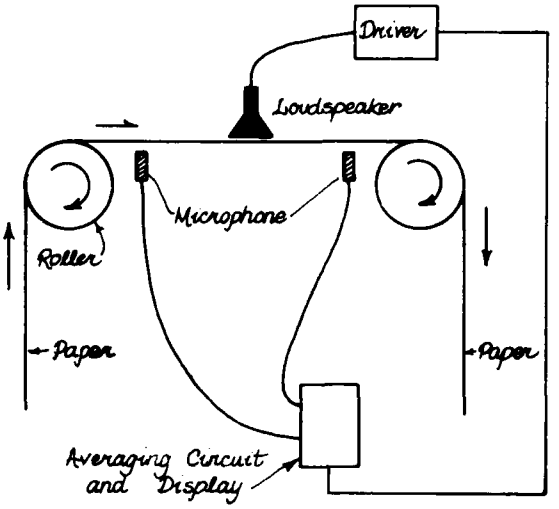


Figure 1

In another interesting development, Luukkala has employed the principles of optoacoustic spectroscopy (See Yoh-Han Pao, *Optoacoustic Spectroscopy and Detection*, Academic Press, 1977) to construct a photoacoustic microscope (PAM) for detecting surface flaws in materials. Figure 2 illustrates the principle.

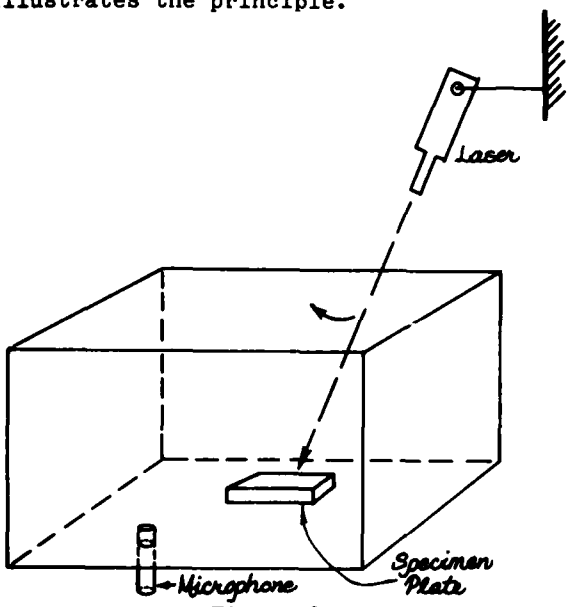


Figure 2

Here a finely focused, chopped-light beam is scanned across a surface. When the light beam strikes the specimen and heats it locally, it also heats the air adjacent to it. If the surface scanned is uniform, a nearby microphone detects only a smooth signal. If there is a surface crack, however, the heat transfer at this crack into the specimen will be less than at other locations. The local instantaneous temperature will therefore rise to a higher level and a stronger signal will result. When a cathode ray tube (CRT) beam is swept horizontally in synchronism with the finely focused light beam and the amplitude of the signal picked up by the microphone is displayed vertically on the CRT face, a map of crack distributions is produced. Other display techniques, along with two-dimensional scanning, can give two-dimensional maps of imperfections.

Luukkala and his group have discovered that the irregularities need not be as drastic as surface cracks. The mere difference in sound level may be caused by different amounts of plastic deformation as, for example, those that occur during the stamping of a coin. They demonstrated this by grinding away the images of a surface of a coin, and subsequently detecting the original imprint from the smooth surface, presumably because of a difference in thermal conductivity caused by different densities of grain boundaries in the material.

While this noncontacting technique produces rather startling results, it suffers from the fact that the specimen should be contained in an airtight cell. During my visit (June 1980), Luukkala demonstrated another noncontacting technique for nondestructive testing that required no such cell. Instead of using a microphone to pick up differences in sound, he used a focused detector to pick up the infrared radiation that is an indication of the local surface temperature. To date, the signals obtained by this technique have been weaker by a factor of about ten than those found by the PAM method. (A 1-watt argon laser was used as the scanning beam.) However, no attempts at optimization have been made as yet. If the method can be developed into a practical technique, it could become very important in nondestructive testing.

In addition to working on problems that are of a very applied nature, Luukkala's group is also engaged in more basic work. Specifically, this is the semiconductor project of A. Lehto and his colleagues, dealing with delayed breakdown, which has led to a possibly new device for infrared detection. Here, in the so-called photochronic detector, the presence of infrared radiation causes a change in the delay of breakdown in a semiconductor that is subjected to a voltage pulse. Until now this scheme has required cooling to 20K and it has not been as sensitive as the cadmium mercury telluride detector. On the other hand, according to what I was able to ascertain, there have not been any extensive attempts at optimization.

I can summarize my visit to Luukkala and his group by stating that it was not only most instructive but also thoroughly enjoyable. The group is certainly full of interesting and clever ideas and is able to demonstrate them successfully. (Irving Kaufman)

SQUIDS IN SUSSEX

The University of Sussex, which is located approximately 4 miles northeast of the center of Brighton, has a modern campus set in over 200 acres of parkland. The university was opened in 1961 and since then has developed a student population of approximately 4,500. I arrived there one rainy morning to visit Dr. Terry Clark of the School (the equivalent of a department in the United States) of Mathematical and Physical Sciences. Clark told me that the Physics School had a faculty of 37 and approximately

60 graduate students distributed among plasma physics, ion implantation studies, atom beams, lasers, cryogenics, and astronomy.

For several years, Clark and his coworkers have been studying noise reduction in superconducting quantum interference devices (SQUID). (See *ESN* 30-2:86 1976.) The SQUID is based on the quantization of magnetic flux ($\phi_o = 2.0678 \times 10^{-15}$ Wb) and the phase-coherent coupling of two bulk superconducting regions by means of a small-area superconducting microbridge--the so-called Josephson weak link. In practice, a SQUID magnetometer usually incorporates a single weak link enclosed by a thick superconducting ring. The AC impedance of the ring plus the weak link is known to be a function of the DC (or low frequency) external magnetic flux on the ring. This impedance which is used to monitor the magnetic flux is determined by inductively coupling the superconducting ring to a parallel LC tank circuit.

In principle the ultimate flux sensitivity of such a system increases as the square root of the AC bias frequency. For this reason the University of Sussex group has chosen to use a UHF bias frequency of 430 MHz, with a resultant flux sensitivity about five times greater than the standard commercial SQUID magnetometer which is biased at 19 MHz. The superconducting ring is patterned after the mechanically and thermally stable SQUID ring first introduced by Zimmerman and his coworkers, in which the point contact type of weak link is held rigidly by means of lock nuts and stabilized by oxidation of the flat niobium portion prior to formation of the contact. The device is constructed so that all adjustments can be carried out when the SQUID ring is operating in a liquid helium bath.

The achievement of this laboratory has been to obtain a low classical-noise input into the SQUID from the preamplifier. Up to the present, Clark has obtained a preamplifier noise temperature of as little as 5.5 K by careful construction, by tuning the tank circuits, and by matching the impedance of the GaAs FET preamplifier, which is also immersed in the cooling bath, to the SQUID tank circuit. The experimental difficulties lie in matching impedances and tuning the tank circuit at the operating temperature of 4.2 K. Impedances can be matched at room temperature, but as the temperature is lowered the carrier mobility in the GaAs FET changes, resulting in a change of impedance of the preamplifier.

Early attempts at impedance matching of the GaAs FET reamplifiers to the tank circuit output were made by mechanically adjusting the capacitors by means of long dielectric screwdrivers which extend to the top of the cryostat. This method was an improvement over existing techniques but tedious. A later refinement has been to utilize gallium arsenide varactor diodes whose capacitance is a function of voltage (approximately $V^{-\frac{1}{4}}$). These have been used successfully both in the tank circuit, where the frequency can be adjusted by approximately 2.5% at 430 MHz operation, and in the GaAs FET preamplifier, where the impedance can be varied between 50 and 75 ohms. In order to attain the necessary stability of the preamplifier it has been found desirable to adjust its bandwidth so that it is larger than the bandwidth of the tank circuit.

Room-temperature electronics include two phase-sensitive detectors: one for the 430 MHz bias circuit, and one for the flux-locked loop. The flux-locked loop can be operated at frequencies up to 10 MHz giving a usable bandwidth of the magnetometer of 5 MHz. At this frequency, and with the system flux-locked, the ultimate sensitivity of the magnetometer is measured as $4 \times 10^{-6} \phi_o/\sqrt{Hz}$ which translates into a signal energy sensitivity of 2×10^{-31} J/Hz at a bath temperature of 4.2 K. Clark claims that this sensitivity is about 4 times better than that observed in other laboratories. Of technical importance in some magnetometer applications is the slew rate which describes how fast the magnetometer can follow changes in the magnetic field. With the device flux-locked at 5 MHz, Clark has observed rates in excess of 2×10^6 ϕ_o/sec. At this rate, the system remains flux-locked with an unlocking probability of approximately 10^{-7}.

One of the graduate students, Mr. M.W. Potts, a former microwave engineer, is constructing a SQUID magnetmometer with a bias frequency of 7.2 GHz. It is expected that this device will have the same noise temperature, better energy sensitivity, and slew rate 100 times larger than the 430 MHz SQUID. These experiments will be carried out in an electrically shielded room with battery power for the electronics and lights. The cryostat containing the SQUID will be rigidly attached to massive concrete blocks in order to reduce "SQUID noise" still more, i.e., signals due to the movement of the SQUID in the earth's magnetic field.

Almost complete when I visited was a small facility for performing sensitive magnetic measurements. The room, a cube 2.44 m (8 ft) on a side, is magnetically shielded with transformer metal and electrically shielded with copper foil. A glass dewar holding the SQUID projects down into the room from the ceiling. Miss H. Rushby, a graduate student, intends to use the room for biomagnetic measurements. She plans that a subject will be placed on a table so that the organ to be investigated may be positioned directly under the dewar containing the SQUID magnetometer. Other projected uses for the shielded room are for observing the transient currents in electrical batteries and the magnetic signal from a dividing cell.

In recent experiments, Clark and his co-workers have cooled the SQUID ring, tank circuit, and GaAS FET preamplifier from 4.2 to 1.8 K by lowering the pressure above the liquid helium bath. As the temperature is lowered below 3 K the behavior of the magnetometer changes radically. With the exception of the first step, all of the usual steps in the voltage-current characteristics of the SQUID begin to smear out and eventually disappear. Accompanying this change in behavior, the classical intrinsic flux noise determined from the first step is extremely small and comparable to the assumed quantum noise flux of the ring. In addition, the observed voltage-current relation shows small periodic structure with spacing equivalent to $(n + \frac{1}{2})\, 2\phi_0$. Clark claims that these observations are evidence for quantized energy levels in the superconducting ring Josephson weak link. A report of these latter experiments has been submitted for publication to *Nature*. (John R. Neighbours)

NEWS and NOTES

MARGINAL ICE ZONE EXPERIMENT (MIZEX)

The initial planning meeting for the international MIZEX program was held in Voss, Norway, from 5 to 8 October 1980. The meeting was partially funded by ONR London.

MIZEX is a logical follow-on to the highly successful 1979 Norwegian Remote Sensing Experiment (NORSEX) that took place north of the Norwegian island of Svalbard and in which the US participated.

The objective of the MIZEX program is to improve understanding and modeling of ice-ocean dynamics and air-sea-ice interaction processes in the MIZ, and to investigate how these processes affect weather-climate-acoustic-chemical-biological actions. Naval operations conducted in the strategic oceanic areas contiguous to the Artic Ocean (Barents, Beaufort, Bering, Greenland, Labrador, Norwegian Seas) require accurate predictive knowledge of ice type/distribution and acoustic propagation characteristics; the MIZEX program is designed to address these requirements.

The following countries will be involved in MIZEX, which is currently proposed for the 1983-86 timeframe: Canada, Denmark, Finland, Iceland, Norway, UK, US, and West Germany.

The first stages of planning centered around presentations of proposed research efforts in MIZ areas by the 12 previously designated discipline chairman. The presentations covered the following topics: physical oceanography, ice/ocean/atmosphere interaction, sea-ice edge, numerical modeling, sea-ice interior, remote sensing of ice, atmosphere, remote sensing of ocean, acoustics, chemical oceanography, biological oceanography, and optical oceanography.

After the presentations had been made the assemblage of 50 persons was divided into 4 working groups according to the geographical scale of each scientist's branch of expertise: large scale (greater than 100 km), mesoscale (10 to 100 km), mechanical scale (10 m to 10 km), and microscale (less than 10 m). The entire group agreed that a series of experiments should be conducted in 3 distinct time periods: in summer, during ice formation, and during ice breakup; and that both deep and shallow waters should be addressed. A majority of the researchers present identified a potential site for deep-water work to the northwest of Svalbard. This "Voss Box" would cover 60,000 sq km laterally (100 km either side of the ice edge by 300 km parallel to the ice edge) by 200 km vertically, from the seafloor upwards. Logistic support will include at least 1 icebreaker, fixed-wing aircraft, helicopters, research vessels, at least 1 drifting ice station, satellites, and hopefully a submarine and a submersible. A 10-man writing committee will convene in December to draw up the MIZEX science plan. Dr. Norb Untersteiner of the National Oceanic and Atmospheric Administration (NOAA) will serve as chairman for this proposal formulation.

Ultimate funding should come, for the most part, from ONR and Norway, with the National Science Foundation (NSF) and possibly the National Aeronautic and Space Administration (NASA) and NOAA contributing a little money. (C.H. Spikes)

ENHANCED ENGINEERING IN THE UK

The recognition in the past decade of the excellence of American instruction in management and the resulting advantages for American industry have led to a spate of government-subsidized, or at least government-encouraged, management schools throughout Europe. A new example of this trend is found in the "enhanced engineering" courses established recently at six leading British universities and one Scottish university. They are encouraged and partially subsidized by the University Grants Committee of the UK, and their nominal justification is "attracting some of the most able school-leavers" (translate "high school graduates") and "training them to make a viable contribution to manufacturing industry"--one of the many efforts of the government to improve British prosperity.

Each of these seven schools has a slightly different program and a slightly different name. They have in common that they require about one full year more than ordinary B.Sc programs at the same school; that they include a heavy load of what are normally thought of as business subjects, including accounting, finance, marketing, organizational behavior, and the like; that they have emphasis on projects (as described often in these pages, especially in *ESN* 32-12:428 [1978]); and that they are small and elite: the total enrollment at the seven institutions is limited to some 300 students per year. At Cambridge it is called "Engineering Tripos"; at Imperial College, "Four-year course in Engineering"; at Brunel, "Special Engineering Programme"; at UMIST, "Engineering Manufacture and Management"; at Oxford, "Engineering, Economics and Management"; and at Birmingham and Strathclyde it has still other names.

At Oxford, there is a 6-week "industrial attachment" in the summer after the second year, and a 6-month "industrial project" starting in the summer of the third year. This project is jointly supervised by the university and the firm, and must satisfy three criteria: it must deal with a real problem, in an engineering environment, which takes a management perspective. These projects are coordinated by Nigel Slack, a mechanical engineer by training whose research is in operations management (production). He holds the posts of lecturer in the Department of Engineering Science (which at Oxford is equivalent to what would probably be called a school of faculty rather than a department at most universities) and fellow in the Oxford Centre for Management Studies, a semi-autonomous organization which gives the instruction (but not the degrees) in management subjects to Oxford undergraduates and graduates, and gets most of its budget by giving post-experience courses to management people in industry.

These programs are well under way in all of the above institutions, but no one has graduated from them yet. While there is nothing exactly analagous in the US, combinations of economics, business, or management with engineering courses have been common at many US universities for a number of years. None of the American programs with which I am familiar have the elitist flavor of these British programs. The students here are specifically described as the "Top Engineers of Tomorrow"; strangely, no mention is made of the possiblility that they might be the managers of tomorrow. (Robert E. Machol)

KEEPING THE BARNACLES AT BAY

Surfaces of ships and boats are vulnerable to fouling by barnacles and green slime and the conventional means of controlling these hazards has been to mix poisonous chemicals (such as ordinary garden herbicides) into the paint applied to crafts' surfaces.

Drawbacks with this method are twofold: firstly, the toxic chemicals quickly percolate into the water (some herbicides are even soluble in sea water) and subsequently become ineffective against the slime; secondly, the modern antifouling coatings presently used can be poisonous to man when they are being applied.

Research into a more effective and safer means of controlling algal slime has been directed by Dr. A. Williams senior lecturer in chemistry at the University of Kent, UK. His work has been aimed at providing the necessary information to enable the manufacture of a new form of marine antifouling paint which has a working life of controlled length and which can be colored in the normal way.

Williams and his team have now devised a method whereby chemicals known to be deadly to barnacles and green slime are incorporated into marine paints in a method which does not just mix them together, but chemically combines within the molecular structure of the paint itself.

Thus, says the university, by using advanced techniques of organic chemistry, the chemicals -or toxin- and the paint will become almost inseparable and should overcome the problem of rapid "leaching" (percolation).

Important consideration in the research has been ensuring that this chemical link is balanced in such a way that a s sufficient amount of the toxin will be released to keep the surfaces of boats slime-free, but for the rate of the release to be controlled so that it remains effective for a much longer period.

On the basis of results achieved in tne university's chemical laboratory over the past 10 years, it has been possible to tailor the molecular architecture of the paint to keep the leaching rate at an optimum level. Another advantage of chemically combining the toxin with the paint will be that the short-term hazards of applying the paint will be removed.

Further information may be obtained from Dr. Williams at the university's chemical laboratory, Canterbury, Kent.

OBITUARIES

Dr. John Apley, CBE, who died on 6 October at the age of 72, was one of the most gifted clinical pediatricians of his generations. He was well known in the US, where he had served at different times as visiting professor at Columbia University and the University of Louisville.

Dr. Arthur Beer, who was widely known in the international astronomical community, died on 20 October. He was 80. in 1975, the International Astronomical Union honored him by giving the name "Beer" to the recently discovered Minor Planet number 1896.

Prof. Herbert E. Watson, emeritus professor of chemical engineering in the University of London, died on 24 September at the age of 94. He achieved recognition early in his professional career by inventing the neon glow lamp in 1911.

European Visitors to the US Supported by ONR London

NOVEMBER

Prof. Birger Rapp of Linkoping Institute of Technology, Linkoping, Sweden will visit DTMB.

DECEMBER

Prof. P.M. Quinlan of University College Cork, Cork, Ireland will visit ONR.

ONRL REPORTS

C-2-80

A Report on the Fifth International Symposium on Nuclear Quadrupole Resonance Spectroscopy held at the Laboratoire du Coordination du CNRS Toulouse, France--10-14 September 1979 by J.C. Carter

The 5th International Symposium on Nuclear Quadrupole Resonance Spectroscopy took place in Toulouse, France, September 10-14 1979. Seven invited lectures and a selection from more than 50 contributed papers are reviewed. The variety of topics covered illustrates the extensive potential of NQR spectroscopy in many disciplines of chemistry and physics. Applications ranging from the characterization of bacteriostatic drugs to the remote exploration for minerals are described. The number of papers reporting double resonance investigations, especially those concerned with the biologically important nuclei ^{14}N and ^{17}O, indicates that significant progress is now being achieved in this field.

C-4-80

9th International Thermal Spraying Conference, The Hague, 19-23 May 1980 by H. Herman

This is a report of the "9th International Thermal Spraying Conference," held in the Hague, Netherlands, 19-23 May 1980. Thermal spraying is a technique whereby protective coatings are formed through melting and high velocity deposition of materials onto substrates. The high temperatures for melting are achieved through combustion, electric arc, or within a plasma. The Conference, though highly technologically oriented, also focused on the scientific bases of processes and materials. The applications cited and discussed included corrosion and wear resistant coatings, erosion resistant coatings, thermal barriers, gas turbine applications, electrical applications, plastic coatings.

Now that all ONRL Technical and Conference Reports published during 1979 and available for unlimited distribution have accessioned by the Defense Technical Information Center, we are pleased to provide this index. Copies of these reports may be obtained from either the Defense Technical Information Center, Cameron Station, Alexandria, VA 22314, or the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, by using the listed AD number.

BIOLOGICAL SCIENCES

R-5-79	B.G. D'AOUST	Current Perspectives in Hyperbaric Physiology, Ultrasonic Doppler Bubble Detection, and Mass Spectrometry (AD-A082519)

MATERIALS SCIENCE

C-3-79	J. PERKINS	1979 Spring Review Course: Phase Transformations, 4-7 April 1979, York (AD-A071357)
C-4-79	W.D. BASCOM	How Plastics Fail--The Churchill Conference (AD-A075433)
C-6-79	A.M. DINESS	Fifth International Conference on Erosion by Liquid and Solid Impact (AD-A088731)

MEDICINE

C-2-79	J. VERNIKOS-DANELLIS	Symposium on Coping and Health, Bellagio (AD-A071356)
C-5-79	I.M. FREUNDLICH	The Fleischner Society Symposium (AD-A074432)
C-7-79	R.F. GOAD	European Undersea Biomedical Society 5th Annual Scientific Meeting (AD-A082019)
C-9-79	I.M. FREUNDLICH	The Sixth Annual Meeting of the International Skeletal Society (AD-A079566)
C-12-79	M.J. FARR	15th International Conference on Applied Military Psychology, 7-11 May 1979 (AD-A083443)

OCEAN SCIENCES

R-1-79	W.V. BURT	Department of Oceanography, University of Liverpool (AD-A073857)
R-4-79	W.V. BURT	Research at the Bidston Branch of the UK Institute of Oceanographic Sciences (AD-A078366)

PHYSICAL SCIENCES

C-1-79	I. KAUFMAN A.K. NEDOLUHA	Fifth European Specialist Workshop on Microwave Active Semiconductor Devices (AD-A067492)
C-8-79	I. KAUFMAN	Physics of Nonlinear Transport in Semiconductors (AD-A080397)
C-11-79	I. KAUFMAN	Electrostatics 1979 (AD-A082917)

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ACOUSTICS

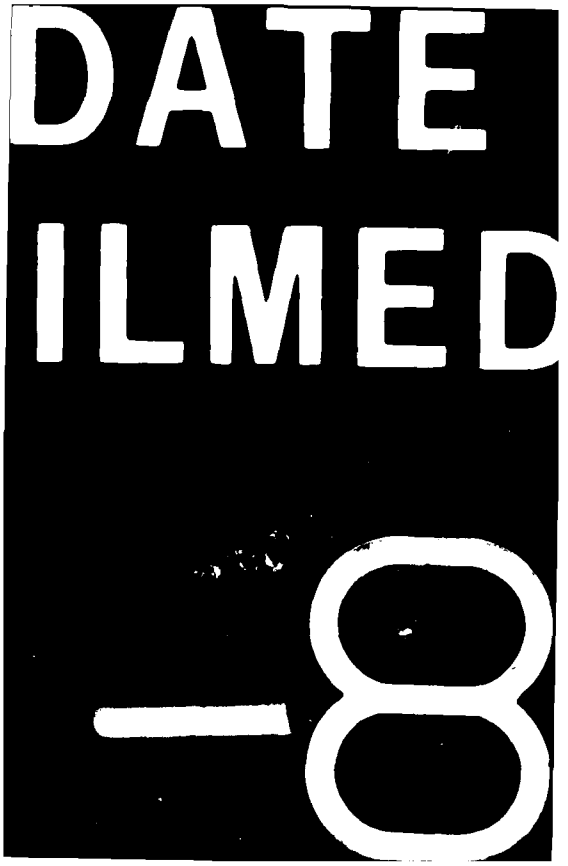
R-3-79	R.J. BOBBER	Developments in Acoustic Transduction in Western Europe

PHYSICAL SCIENCES

R-2-79	F.C. ALLARD A.S. GLISTA D. HART T. MEADOR D.N. WILLIAMS	Fibre Optics Activities in Europe: A Report on the June 1978 Survey

TECHNOLOGY

R-6-79	J. COATES T.W. DINNISON J.A. GUINN A. HOBOKAN H.R. HOPPER M.K. MILLER P.D. THOMPSON P.A. VOHS C.C. ZINN	Operation Technology Exchange Report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